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THE STUDY OF INSECT BEHAVIOR AS A STUDENT BIOLOGY PROJECT

by

ROBERT A. FRANZ

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "The Study Of Insect Behavior As A Student Biology Project", submitted by Robert A. Franz, in partial fulfilment of the requirements for the degree of Master of Education.

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ABSTRACT

Four interrelated fields within the secondary school biology program were investigated in this inquiry. These were the project method, the utilization of live organisms, the study of animal behavior and plant tropisms, and the study of insects. Eighteen secondary school biology teachers in southwestern Alberta were interviewed between April 30 and May 4, 1973, to investigate the nature and extent of project implementation and live organism utilization and to obtain teacher opinions on the advantages and disadvantages of implementing projects involving insect behavior.

Few correlations were found between various aspects of the teacher's background and his teaching methodology and considerable variety was found in the various methods of project implementation. A majority of the teachers interviewed were using the project method and a majority of the teachers felt that projects were most valuable in developing the process aspects of biology and in providing for individualized instruction. Although 94.4% of the teachers used live organisms and 83.3% used feral organisms, the diversity of organisms utilized and the length of utilization was found to be low. Relatively few projects involved the use of insects or the study of behavior.

The information obtained from the teacher interviews was used to devise 12 student guides dealing with insect behavior. This was supplemented by recommendations from the available literature, consultation with members of the Department of Entomology at the University of Alberta, and examination of equipment used in that

department. These projects were devised between June 1 and July 31, 1973. Fourteen secondary school biology students conducted six of these projects in the fall semester. A total of 10 insect species were cultured by the students for use in these projects. The students were interviewed between December 14 and December 20, 1973, to obtain their opinions on the advantages and disadvantages of conducting projects involving insect behavior and to evaluate the effectiveness of the student guides devised by the writer.

Students indicated that the projects were most valuable in developing an understanding and appreciation of live organisms and in providing content which was relevant and interesting to the student. A majority of the students indicated that the main values of the student guides were the provision of background information and the provision of guidance in experimentation and interpretation of results. Few problems were encountered in experimenting with and culturing insects and all students indicated satisfaction with the student guides used.

From the apparent success of the projects implemented in this inquiry, it would appear that there are several advantages in using insects in student projects and that the study of insect behavior is feasible at the secondary school level. From the results of this inquiry, the writer has offered several recommendations on the utilization of the project method and on the implementation of projects involving insect behavior to assist teachers in the utilization of living organisms in their classroom instruction.

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CHAPTER I

INTRODUCTION

I. BACKGROUND TO THE INQUIRY

This inquiry dealt with four distinct but interrelated fields within the secondary school biology program. These fields were the use of projects, the use of live organisms, the study of animal behavior and plant tropisms, and the study of insects.

The pros and cons of the project method have been debated by pedagogical theorists ever since the method was first proposed over 50 years ago. Concern over this topic has been renewed locally with the incorporation of a project unit in the Alberta Biology 10 and 20 curricula in September 1969 and in the Biology 30 program in September 1971. The current Alberta biology curriculum guide (1971) suggests four general objectives for the high school biology courses:

1. To enable the student to familiarize himself with his immediate biological world, and to realize the importance of the interdependence of living organisms and the part man plays in this scheme

2. To develop the ability of a student to carry out successful independent study and learning

3. To develop sound procedures for biological field and indoor laboratory study

4. To develop an understanding of and an appreciation for the methods used by scientists; the means and conditions under which science advances; the role of biologists; the importance of accurate and accessible records, constantly improved instruments, and free communication.

Comparing these general objectives with those suggested in the guide as objectives of the project method, a close parallel can

be seen:

a) To give each student an opportunity to do an in-depth study in an area of his interest

b) To encourage students to formulate questions for investigative purposes

c) To further familiarize students with research methods and procedures

d) To enable students to practise methods of proper scientific reporting

e) To permit the development of empathy with the scientific researcher.

Since the project system had been in use in Alberta secondary biology courses for four years, it seemed appropriate to the writer to determine the organization and extent of implementation of projects in at least a number of secondary school biology classrooms.

Orlans (1968) has noted that the use of live organisms in the classroom has increased over the past twenty years with increased emphasis on learning scientific principles by performing experiments. Similarly, the introduction of the project method has been accompanied by an increase in the opportunities for the utilization of living organisms. However, informal discussions with other biology teachers throughout the province at both regional and provincial conferences appeared to indicate that a minimal number of live organisms were being used in Alberta schools. Recent research by Jacknicke (1968) and Dyke (1970) has confirmed this observation and both have recommended that there be further studies to determine the extent to which local resources are being utilized. With the inclusion of projects in all levels of secondary school biology in Alberta, it seemed desirable to determine the present use of live

organisms in these projects and to compare the findings with the results of these earlier studies.

In order to supplement and update earlier research on the use of projects and the use of live organisms, this inquiry also attempted to investigate, within the project context, two areas of biology that do not appear to have been treated by previous research--ethology and entomology. Ethology, being a relatively new science, has received attention only in approximately the past ten years, and entomology, covering such a large collection of species, does not appear to the knowledge of the writer to have been treated in depth.

II. PURPOSE OF THE INQUIRY

The purpose of this inquiry was to investigate how projects dealing with insect behavior can be implemented and conducted. Three avenues of research were utilized in an attempt to achieve this purpose. First, 18 teachers were interviewed to determine the nature of projects dealing with insect behavior as they were currently being conducted in a sample of secondary school biology classes in southwestern Alberta. The school systems covered in this sample are listed in Appendix I.

Second, analysis of the data obtained from the interviews and a survey of the available literature served as the basis for the development of a series of projects dealing with insect behavior. This was supplemented by consultation with members of the Entomology Department, University of Alberta, and examination of the equipment used in that department.

Third, these projects were then implemented in the classroom by several of the teachers involved in the initial interview besides by the writer. The results of this implementation were analyzed by the writer through the use of student interviews.

It was on the basis of these three procedures that the ultimate goal of this inquiry was reached: to formulate recommendations on the implementation and organization of projects dealing with insect behavior to assist teachers in the utilization of living organisms in their classroom instruction.

More specifically, this inquiry attempted to answer the following major questions:

1. To what extent are secondary school biology students in the selected school systems of southwestern Alberta conducting projects dealing with insect behavior?
2. What are the advantages and disadvantages of implementing projects dealing with insect behavior as perceived by the teachers of this sample?
3. How might factors limiting or hindering student research into insect behavior be minimized?
4. How might insect species be used in the study of behavior?

The initial teacher interview was designed in an attempt to provide answers to questions one and two. The construction and implementation of projects dealing with insect behavior was followed by an analysis through the use of student interviews in an attempt to answer questions three and four.

Besides these primary concerns, the inquiry attempted to answer four additional questions. Answers to the following questions

were derived from the initial teacher interviews and used as guidelines in the construction of projects dealing with insect behavior.

1. To what extent are projects being implemented in secondary school biology classrooms in this sample?
2. To what extent are local, living organisms being utilized in student projects in secondary school biology classrooms?
3. To what extent are live insects being utilized in student projects?
4. To what extent is behavior being investigated in student projects?

III. LIMITATIONS OF THE INQUIRY

The sample used in the interview of teachers was restricted to secondary schools in the indicated school systems of southwestern Alberta, and as such, the findings reflect the educational climate of that area. The sample interviewed was further restricted to secondary school biology teachers although it is recognized that other teachers may be studying animal behavior and using live organisms. This was deemed necessary by the writer in light of the scope of the projects to be constructed and the sector of the school population that would be using them. The procedures used to select these teachers and implement the projects are discussed in Chapter III.

To facilitate the handling of the data obtained, the advantages and disadvantages of using projects were restricted to those dealing with insect behavior. Similarly, the advantages and

disadvantages of using live organisms were restricted to insect species on the initial teacher interview.

In the construction of projects dealing with insect behavior the exercises proposed in the inquiry were limited to those which the writer felt could be conducted by secondary school biology students. The projects dealt only with easily obtained insect species and the exercises suggested were restricted to those involving common and unsophisticated equipment.

The sample used in the interview of students was restricted to secondary schools involved in the interview of teachers. The sample interviewed was further restricted to those students who had elected to study insect behavior. The opinions stated by these students in the interviews may possibly reflect their personal interests in insect behavior. Students in the writer's classes also may have been influenced by the fact that they were being taught and evaluated by the writer.

IV. DEFINITION OF TERMS

To clarify the terms used in the inquiry, the following definitions of the major terms are provided here for ready reference.

<u>Abiotic Stimuli</u>

Those signals which arise from nonliving matter.

<u>Accessibility</u>

The ease with which local resources can be obtained or the ease with which students can be taken on field trips to study local resources. This definition was provided for each teacher during the

interview.

Agricultural and Forest Entomology

That branch of applied entomology dealing with crop and forest interrelationships with insects.

Applied Entomology

That branch of entomology concerned with the application of scientific principles to the solving of problems of insects that are harmful or beneficial to man.

Behavior

The responses of an organism to its environment, both in the natural habitat and in experimental laboratory conditions. Behavior includes both animal responses and plant tropisms.

Biology Course

Any subject in which at least 50% of the instructional time was spent on living organisms, their life processes, or their relationships to each other or to the environment.

Biology Methods Course

Any university or college course involving curriculum and instruction in the biological sciences.

Choice Chamber

Any apparatus providing an experimental organism two alternative stimuli to determine which of the two stimuli is the more favorable.

Class Project

Any project initiated by the teacher and/or students but conducted jointly by all members of the class.

<u>Commercial Organisms</u>

Any organisms which are obtained from pet stores or biological supply houses.

<u>Comparative Behavior Project</u>

The analysis and comparison of behavioral patterns exhibited by different groups of organisms.

<u>Concurrent Implementation</u>

The implementation of projects at the same time as other aspects of the course in contrast to unit implementation.

<u>Coordinated Behavior</u>

Behavior consisting of a series of simpler reactions and responses related to each other to result in a unified act or behavior pattern.

<u>Culturing</u>

The cultivation of living organisms so as to promote their growth and encourage their reproduction.

<u>Ecology</u>

That branch of biology dealing with the relationships of living organisms to their environment and to other living organisms.

<u>Entomology</u>

That branch of biology dealing with the study of insects.

<u>Error of Central Tendency</u>

The tendency of raters to avoid using the extreme positions on a rating scale.

<u>Error of Leniency</u>

The tendency of raters to be overly generous in descriptions.

Ethology

That branch of biology dealing with the innate behavior patterns of living organisms in response to both biotic and abiotic stimuli.

Feral Organisms

Those organisms, native or introduced, found living under natural conditions as opposed to commercial organisms.

Field Trip

A visit made to a particular area for the purpose of first hand observation. This visit is usually selected and organized by the teacher.

Full Year University Course

A course offered for the duration of one university year in contrast to one offered for one semester.

General Behavior

The overall responses composing the behavior of an organism.

Generalizable Knowledge

That accumulation of background information which can be applied to a variety of specific situations in contrast to incisive knowledge.

Gradient

Any apparatus providing an experimental organism with a change in intensity of a stimulus per unit distance to determine which intensity is the most favorable.

Group Project

Any project conducted by two or more students but not by all members of a class.

<u>Incisive Knowledge</u>

That accumulation of background information which can be used to discriminate between and critically analyze new concepts.

<u>Individualized Instruction</u>

Any teaching methodology designed to account for individual interests and differences in learning capabilities.

<u>Individual Project</u>

Any project conducted by one student.

<u>Innate Behavior</u>

Behavior in which reactions to stimuli appear to be predetermined. Innate behavior is unchanged by learning.

<u>Instinct</u>

A complex, relatively rigid inherited pattern of behavior released by a complex environmental situation and leading to the satisfaction of an inner drive.

<u>Kinesis</u>

An undirected locomotory reaction in which the rate of movement or the frequency of turning depends on the intensity of the stimulus.

<u>Laboratory Exercise</u>

An investigation involving structured procedures and usually minimum opportunities for student initiative in designing and interpreting the investigation.

<u>Learned Behavior</u>

An adaptive change in behavior based on experience and differing from individual to individual.

<u>Likert Scale</u>

A scale in which the respondent is asked to indicate the degree of agreement or disagreement with a set of unscaled items.

<u>Maintenance Facility</u>

The relative ease of collecting, culturing, and utilizing a live organism in comparison with other species.

<u>Medical and Veterinary Entomology</u>

That branch of applied entomology dealing with parasites and disease in relation to insects.

<u>Mechanical Stimuli</u>

Those of gravity, pressure, sound, and touch.

<u>Natural Resources</u>

Those materials, living and nonliving, supplied by nature.

<u>Operational Thought</u>

A process of reasoning based on an organized collection of concepts. Concrete operations are those in which these concepts are used to apply logical thought to practical problems and concrete situations. Formal operations are those in which these concepts are used to apply logical thought to abstract situations.

<u>Phototaxis</u>

Movement in a specific direction in relation to the source of light. A movement towards the source of light is a positive phototaxis. A movement away from the source of light is a negative phototaxis.

<u>Process Approach</u>

Any teaching methodology designed to encourage students to understand and exhibit skills, methods, and attitudes associated

with a particular field of knowledge. In secondary school biology courses this approach could include the learning of laboratory skills, the practising of proper methods of scientific reporting, and the developing of attitudes of curiosity and inquiry.

Project

An activity guided by the teacher but selected and carried out by the student or a group of students and involving laboratory and/or field research and the writing of a report. In contrast to field trips and laboratory exercises, the procedures are usually selected by the student.

Rhythmic Behavior

Behavior which occurs in a regular cycle.

Rural Schools

Those schools whose student population is derived from a rural area.

Secondary School

Any Alberta institution offering instruction in at least Grades 10, 11, and 12.

Social Behavior

The behavioral responses of a group-living organism to others in the group but not to organisms which are not members of that group.

Stored-products Insects

Those species of insects infesting stored domestic and commercial supplies.

Taxis

A directed locomotory reaction towards, away from, or at a

constant angle to the stimulus.

Teaching Experience

The total number of years of classroom teaching disregarding grade level and subject area.

Tropism

A nonlocomotory response in which an organism bends towards the stimulus. Tropism usually refers to plants and sessile animals.

Unit Implementation

The implementation of projects in a single block of time consecutively with other aspects of the course.

Urban Schools

Those schools whose student population is derived from an urban center. For the purposes of this inquiry, urban schools were those in the Lethbridge School District Number 51 and the Lethbridge Catholic Separate School District Number 9.

CHAPTER II

REVIEW OF RELATED LITERATURE

I. THE USE OF PROJECTS

Theoretical Research

The project method, in one form or another, has long been recommended by pedagogical theorists. The activity method suggested by Rousseau in the eighteenth century, the "education-room" suggested by Froebel (1887) in the nineteenth century, and the problem method suggested by Dewey (1938) in this century all closely resemble the philosophy behind the project method, both in intent and in conduct. Bleeke (1968) has conducted an extensive investigation into the history of the project method in the United States.

It was under the leadership of William Heard Kilpatrick, however, that the project method received its greatest emphasis on this continent. Kilpatrick (1935) felt that the project method could be used to achieve three main objectives. The immediate objective was the provision of experiences that lead the student on to further knowledge; the intermediate objective was the acquisition of desirable learning outcomes such as knowledge, skills, habits, and attitudes; and the remote objective was a higher level of living due to the acquisition of these outcomes. To accomplish this, he suggested that a course of studies should include the following:

"1. A clear account of the theory, with emphasis on the new kind of aims [involved in the project method].

"2. A few specimen projects of various sorts worked out in

detail to show the kind of thing to be expected and why, with a study of the correlative outcomes.

"3. A list of suggestive projects much larger than could possibly be used, with appropriate reference materials and suggestions for equipment.

"4. Some account of outcomes reasonably to be expected, with emphasis on habits, attitudes, and appreciations, since these have too generally been overlooked--such outcomes not to be held up as immediate objectives but to help the teachers and pupils estimate their own progress.

"5. Some self-teaching and self-testing drill materials with a statement of correlative desirable standards."

Since the emphasis on the project method in the 1920's and 1930's, various educators have written in support of the approach, proclaiming a variety of advantages inherent in the project method for the achievement of not only the preceding objectives but also many other goals. Among the more recent articles are those by Kastrinos (1956), Washton (1967), Chancey (1968), Duffy and Putt (1969), Richardson (1959), Campbell (1973), Huffmire (1961), Simmons (1961), and Sternlicht (1965). These were theoretical articles and no evidence was cited for the claims made by the authors. At the same time a number of educators have pointed out the disadvantages and dangers related to the use of projects, two of the more comprehensive reports being the papers presented by Banser and Bagley (1921) at a symposium on the difficulties of the project method. The learning requirements for the inquiry method of instruction suggested by Gagné (1963) are closely related to potential problems in using the project method. For a secondary school student to be able to formulate and test hypotheses critically, Gagné noted that he needs generalizable and incisive

knowledge. This knowledge must include not only factual knowledge but also knowledge about such methods as observing, inferring, and conceptual invention.

The theory of sequential cognitive development suggested by Piaget (1952) might account for some of the problems encountered in the project method. Piaget has suggested that as a child develops he is capable of handling stimuli more and more remote from himself in time and space. Cognition is seen as a function of experience, intellectual sophistication, and age. Between the ages of seven and 11, the child is typically at a stage of mental growth Piaget refers to as the period of concrete operations. During this period the child is capable of logical thought based on a set of concepts which have been internalized into organized systems. The child can deal with classes, relations, and numbers and he can apply operational thought to practical problems and concrete situations. Between the ages of 11 and 15 the child enters the final period of development, the period of formal operations. At this time he develops the ability to think in abstract terms and to consider hypotheses and the possible consequences if the hypotheses are true.

Brown (1965) noted that it is at the formal operations period that the child is capable of working like a scientist. Berlyne (1964) further noted that it is at this final stage that the hypothetical-deductive processes of science are open to the child and that "not before the formal-operations stage does the child plan truly scientific investigations, varying the factors in all possible combinations and in a systematic order." Theoretically, students enrolled in secondary school biology classes should be in this final

stage of mental development. The project method would provide these students an opportunity to practise scientific skills and methods.

However, Inhelder and Piaget (1958) have indicated that although all children go through the stages of mental development in the same order, they do not develop at the same rate and that the suggested ages for each stage are not absolutely fixed. This has also been noted by Brown (1965), Lefrancois (1967), and Buell and Bradley (1972). It is possible for secondary school biology students to be at the stage of concrete operations. This has two major implications with respect to the project method. First, teachers should be aware of the fact that some students may not be capable of forming hypotheses and devising scientific experiments and that some students will require assistance in these aspects. Second, teachers should provide projects within the capabilities of a child in the concrete operational period and teachers should modify the objectives of the project method accordingly.

Other criticisms are cited in the literature on educational theory but the authors are not identified. These criticisms include complaints that students "do not learn as much", that the method is time consuming, that it requires extra work on the teacher's part, and that there is a lack of reference material and equipment. The validity of those theoretical statements directly related to the areas covered in this inquiry will be examined in more depth when discussing the findings by the writer.

Experimental Research

Experimental research has been sparse and the findings

contradictory. In describing experiences with the project method, Brown (1967) noted that curiosity and enthusiasm were developed, research was stimulated, and the students learned basic techniques in animal care. Furthermore, he noted that experimentation requires careful observation, patience, and perseverence, all of which are desirable traits to be developed in students, and that his project class had a "ten point advantage" on laboratory tests and informal quizzes. However, the nature of these tests and his method of evaluation were not indicated.

Similarly, in discussing projects conducted by 340 students in grades nine to 12 for four one-week periods Foster (1970) reported that the program had an impact on student value systems and increased their maturity "to an observable extent". Among the student opinions cited were the views that the project was worthwhile and relevant, that they could study on their own and at their own speed, that they had to work harder, that they found it difficult to discipline themselves, and that they felt some of their classmates were too immature for the responsibilities involved in the project method.

West (1956) further reported success with a biology methods course which included four to six hours a week on projects. He noted that teachers who have taken the course later have pupils who submit "excellent and numerous" secondary school exhibits at regional fairs. In describing the use of projects in secondary school biology classes, Colyer (1962) observed that projects "allow creativeness, discovery, incite interest, expand learning, and enhance the field of science to the student."

The validity of these four articles is obscured by the lack of explanatory notes on testing devices and control of variables, and their inclusion as experimental research might be questioned. In Ausubel's (1963) terms, these descriptions of existing programs might be considered "enthusiastic but wholly subjective testimonials", but they are representative of much of the literature on the project method.

Novak (1958) described an experiment involving 522 students in two introductory botany courses at the University of Minnesota, one group having received the conventional lecture method and the other group covering the same material but at a faster rate so that six weeks could be devoted to projects. A problem-solving pretest, a botanical facts and principles pretest, and a scientific attitudes pretest were administered and then compared with factual and practical tests during the course, a problem-solving post-test, a scientific attitudes post-test, and a fact retention post-test.

He found that those students taking the conventional course retained facts best and were less variable on tests for botanical knowledge. It was also found that the project method provided for individual differences better and that the project group was superior in problem-solving and scientific attitudes tests, but not at a significant level. In considering these findings, it should be remembered that this study dealt with college students and that the coverage of material by the two groups was at a different rate which may account in part for their differences.

In studying the outcomes of participation in science project activities, Hale (1967) administered a science process-

product test and a science interest test to 952 grade nine students and asked teachers to rank them on scientific knowledge and understanding of processes. After science projects were completed for a science fair, the same or equivalent tests were given, the teachers ranked the students a second time, and a questionnaire was given to the students.

Hale found that project making had no effect on a student's achievement or interest in science. The teacher and the school were found to be the greatest motivating factors rather than awards, class time, or grades. He also found that the majority of the students involved in projects would not have participated in projects if they had not been required to do so, and that although a majority of the students felt that they had learned something, a large minority did not feel that they had. Unfortunately, these were items checked off on the questionnaire and no attempt was made to determine the reasons for these responses in the study.

Hale noted that students who did investigation type projects excelled in achievement over those making construction type projects but not over those making demonstrations or no projects at all, this inconsistency suggesting the need for further study. The greater the number of years a student conducted projects the more likely he chose science as a career, but whether the career choice was due to projects or vice versa was not determined from the data collected. These results must be considered with reservation since the study involved grade nine students working on projects for a science fair and thus might not be applicable to other types of projects.

In contrast to these findings, Cowan (1967) reported that introduction of the project method into the fourth year of the English secondary school improved working standards, understanding, discipline problems, interest, and attendance of the 56 students involved. However, the entire class concentrated on one central theme and a number of subject areas were integrated in order to conduct the project so again application to this inquiry is limited.

Local Research

Two studies have been conducted on the project system in Alberta secondary schools. Anderson (1972) interviewed 10 urban and eight rural teachers in the Edmonton school system and the Peace River District and administered a questionnaire to 340 urban and 220 rural students in grades 10, 11, and 12 to determine the organization and implementation of biology projects. He found that of the rural sample, 71% of the teachers conducted projects in grade 10, 71% conducted projects in grade 11, and 80% conducted projects in grade 12 whereas the percentages for the urban sample were 72.8%, 33%, and 100% respectively.

These results would indicate that despite the theoretical advantages of the project method and the Department of Education recommendation that projects be conducted in all three biology courses, there are limitations in its implementation and there is a need to assist teachers in overcoming these problems. Among the problems identified by Anderson's study were lack of space and reference material, lack of teacher experience with projects, and

large classes.

Anderson also found that 100% of the rural sample conducted projects concurrently with the course material compared with 36.3% of the urban sample. The significance of this finding for this inquiry is noted by Anderson:

> The prime advantage of the single-unit approach is its short time-span which prevents the student from becoming bored with his project as he may do in the concurrent method. Conversely, however, it is impossible to carry out many experiments, such as population surveys or animal behavior studies, under the unit method. The teacher who uses the single-unit approach is therefore placing considerable restriction on topics.

These findings by Anderson, besides his findings on project implementation and teacher opinions will be analyzed in more detail in comparison with the findings by the writer.

In contrast to Anderson's findings, Darroch (1972) found in an interview of seven urban and seven rural Biology 30 teachers in Edmonton and the neighboring districts that 77% ran their projects concurrently and 23% devoted a unit of time to project work related to Unit II of the biology course (current biological problems). Fourteen percent of the teachers reported that none of the projects conducted were related to Unit II and 65% of the teachers indicated that only 15 to 30% of the projects were related to this unit despite the recommendation by the Department of Education that Biology 30 projects be in the area of conservation or pollution. A study conducted by Dr. Paul Paetkau at the University of Alberta on the use of projects in the area of ecology should provide additional information on this topic.

Among the reasons cited for the lack of projects related to

current biological problems were the need for laboratory space and equipment and the lack of familiarity with the local environment. Thus, this study again points out the need to assist teachers in utilizing their local resources to supplement material in the text and the need to provide illustrations for possible project activities. However, care should be taken in applying the results of these two studies since both are based on small samples of the total teacher population.

II. THE USE OF LIVE ORGANISMS

Although a considerable number of educators have recommended the use of live organisms in the classroom [Smith (1960), Halmquist (1960), Ratzlaff (1972), Mayer (1973), Weinberg (1962), and Taylor (1965)], others have cautioned teachers on the proper care and humane treatment of live animals [Animal Welfare Institute (1960), Orlans (1968), Jernigin (1971), Rowsell (1969), Ansevin (1970), and Russell (1972)]. Despite the advantages and values of using live organisms claimed in these papers, no comparative research showing the effect of live organism utilization on student achievement could be found by the writer.

Research available on the extent of live organism utilization, on the other hand, has been consistently negative on this continent. Abbott (1954) sent out a questionnaire to 120 schools in the United States. From the 45 returns, he found that teachers rely mainly on charts and specimens preserved in bulk (35% and 24% of all cases reported respectively). Permanent demonstration preparations accounted for 16% of the cases and microscope slides for

12% whereas only eight percent of the cases involved the use of live organisms.

In investigating the use of fresh-water organisms in Alberta Jacknicke (1968) interviewed 11 teachers of Biology 20 or grade eight in the County of Lacombe. He found that 64% of the teachers collected or used local organisms but only 18% of these cases actually involved teachers in the collection activity. The most frequently used groups were protozoa (reported by 63% of the teachers), arthropods (63%), and chordates (36%). Only 36% of the teachers surveyed cultured organisms. When asked why teachers might not use local organisms, the teachers offered the following three major reasons: it was too time consuming; teachers had inadequate knowledge of what organisms were available, where they could be found, how to culture them, or how to collect them; and there was a lack of facilities for collection and culturing.

Similarly, Dyke (1970) found in an interview of 30 grade eight teachers in Edmonton that only 20% of the teachers used live mammals and only seven percent used feral mammals. The reasons given by teachers for not using live feral mammals were again extra teacher involvement, lack of facilities, and a lack of teacher knowledge.

From these studies, it would appear that despite the suggested advantages of using live organisms, most teachers are not using such resources. However, these studies involve small populations and both Alberta studies include junior high school science teachers in the survey so a direct application of these results to secondary school biology is not possible. Besides,

these studies were conducted before the project system was introduced into the entire biology program. The introduction of the project method may have altered the extent of live animal utilization. Furthermore, the elimination of departmental examinations in 1973 might have encouraged a decrease in emphasis on the learning of content and a corresponding increase in the activity aspects of the Biology 30 program. A study dealing with the use of plants in secondary school biology currently being conducted by Mr. Gary Schofield at the University of Alberta should provide more information on the utilization of live organisms in Alberta classrooms.

In contrast to these studies, a survey on the use of live organisms in England by Kelly and Wray (1971) presents a considerably different picture. A questionnaire was sent to 257 secondary schools, and from the 193 responses over 100 species of organisms were reported in use. Micro-organisms, plants, insects, frogs, mice, and gerbils were the most abundant organisms used. Schools depended mainly on purchasing organisms, although amphibia, reptiles, plants, and invertebrates other than insects were usually collected. Insects and small mammals were the only groups bred to any great extent.

The major problems noted by teachers were feeding, breeding, and maintaining organisms over holidays. Supply, housing, and handling were problems only with a few specific species. From these results, Kelly and Wray concluded the three major needs were the establishment of maintenance facilities for species to assist teachers in their choice of organisms, the establishment of

organizational arrangements to care for organisms over holidays, and the establishment of purpose-built organism accomodation in schools.

No clear reasons for the different results obtained in this study can be noted. The Nuffield Science series implemented in English schools prior to the Kelly-Wray study emphasizes the use of living organisms and natural history, which may account in part for the findings. However, to the knowledge of the writer no studies have indicated a change in live organism utilization with the introduction of American biology programs also emphasizing the use of live organisms.

III. THE USE OF ETHOLOGY PROJECTS

No research could be found on the advantages and disadvantages of projects in ethology nor directly on the extent of their use. Jacknicke (1968) did find that of the seven teachers using fresh-water organisms, five used them for classification, four for microscope work, and two for manipulation of materials. Among the miscellaneous topics listed applicable to this inquiry were the life cycles of insects, awareness of the local environment, training in observation, examples of animal movement, and stimulation of interest.

Similarly Dyke (1970) found that of the six teachers using small mammals, three teachers used them to study structure, two to study feeding habits and diet, two to study conditioning, two to study general behavior, and one teacher for each of the following: reproduction and growth, locomotion, display, and the effect of

drugs on behavior. It should be noted that most of these uses are ethology topics. However, when asked for suggestions on how feral mammals might be used only 27% (eight teachers) suggested behavior compared with 60% suggesting the study of structure, 60% suggesting the study of ecology, and 30% suggesting the study of reproduction.

For the first time in the history of the Nobel citations, the 1973 prize in medicine was awarded to three behavioral scientists. The recipients were Konrad Lorenz for his research on the behavior of birds, Nikolaas Tinbergen for his research on the behavior of fish, and Karl von Frisch for his research on the behavior of insects. Ethology has become an influential science only in approximately the past ten years and only recently have a number of educators recommended the inclusion of a course on behavior in the curriculum /Lokke (1962), Scherba (1967), Polt (1971), Gantert (1965), Crossman (1967), Shepley and Coultas (1971), and Demchik (1973)/. J.P. Scott (1962) suggested that a course in ethology would unite various disciplines of biology since the causes of behavior are:

> related to genetics, anatomy, and physiology as well as to the process of learning and external stimulation. Behavior itself is the building block of social organization and, in turn, of the organization of populations. Thus it is possible to relate most of the facts of biology to behavior in a natural and interesting manner.

In describing a course on the social behavior and organization of vertebrates for graduate students in biology and psychology who were teaching in the schools, H.J. McKenna (1971) concluded:

> Let me emphasize the importance of developing a course in biology that is more relevant to our students--a course

that will attempt to tie in our environmental problems, war, conflict, and other social questions with the living world around us. In addition, many students have not found themselves, and a course that will allow them to understand themselves better as a part of nature should open the door to discovery and make for a better social human being.

IV. THE USE OF INSECTS

As in the case for the use of ethology projects, no research could be found showing the advantages of using live insects over any other method although a number of educators have recommended the use of live insects in the classroom [Lener (1963), Masteller (1970), Hadley (1953), Backhouse (1972), Hanawalt (1954), Mohler (1963), Bates (1973), and Zipko (1973)]. In discussing the ways stored-products insects can be used in the classroom, Mills (1966) noted the following advantages:

1. They can be studied in nearly natural habitats.
2. Most have short life cycles if conditions are favorable.
3. They are easily obtainable and inexpensive to maintain.
4. They require a minimum of attention.
5. Not only can they be used for the entomological part of biology, but also as examples for discussion of important biological processes common to all animals.

If these claims are valid, then it is probable that the use of insects can overcome several of the major problems indicated by teachers and theorists in the research summarized in the preceding sections.

Only two studies could be found dealing with the extent of insect utilization. Jacknicke (1968) found that of the seven teachers using fresh-water organisms, five used insects. This was the most common group of arthropods used. The most common insects

were ants, bees, wasps, flies, butterflies, and moths. However, usually only one kind of organism was used by each teacher and none collected aquatic insects or aquatic larvae. Only one teacher cultured arthropods, this being an ant and a bee colony for observation purposes. An extensive summary on culturing attempts was also included in the study.

Kelly and Wray (1971) did not indicate the extent to which insects as a group were used, but they did list the use of individual species and the percentage of schools using them. These species were the locust (72% of the schools reporting their utilization), cockroaches (42%), stick-insect (64%), bee (34%), mealworm beetle (16%), Drosophila (13%), flour-moth (seven percent), and Tribolium (five percent). All of these were cultured by at least some of the schools, the exact percentage not being indicated in the paper.

V. SUMMARY OF RELATED LITERATURE

A large percentage of the literature on the project method has been of a theoretical or a testimonial nature. The theories proposed by Gagné (1963) and Piaget (1952) have indicated potential problems in the inquiry method of instruction. Experimental research has indicated that the project method provides for individual differences and improves student interest, working standards, and understanding. A low correlation has been found between the use of projects and problem-solving ability, scientific attitudes, and choice of science as a career. Conversely, other research has found no relationship between the use of projects and student achievement

or interest.

No research could be found dealing with the effect of projects on student achievement in Alberta. Research by Anderson (1972) and Darroch (1972) has indicated that the majority of secondary school teachers conduct projects but that lack of space and reference material, lack of experience with projects, large classes, and lack of familiarity with the local environment were serious problems. This inquiry investigated both of these aspects of project utilization. The effect of the project method on the learning of content and development of skills and attitudes was investigated by implementation of projects followed by student interviews, and the advantages and disadvantages of the project method were investigated by a survey of 18 secondary school biology teachers.

Despite the large number of papers recommending the use of live organisms, research has shown that with one exception in England teachers are not making use of this resource. Jacknicke (1968) found that seven out of 11 Biology 20 and grade eight teachers interviewed used local fresh-water organisms and Dyke (1970) found that six out of 30 grade eight teachers interviewed used small mammals. These teachers indicated that possible reasons for the lack of live animal utilization were the extra teacher involvement and time consumption, lack of teacher knowledge, and lack of facilities. Since the former study was conducted before project implementation in Alberta secondary schools and the latter did not deal with secondary schools, this inquiry investigated the extent of live organism usage by 18 secondary school biology

teachers and the advantages and disadvantages of implementing projects dealing with insect behavior.

Few studies could be found on either the study of behavior or the use of insects at the secondary school level. Dyke (1970) found that small mammals were used mainly for the study of behavior and related topics in grade eight. Jacknicke (1968) found that the majority of the arthropods used were terrestrial insects but there was only one report of culturing insects. The use of invertebrates for behavioral studies was of minor occurrence according to his study. This inquiry investigated both the extent of usage and the problems and advantages of implementing projects dealing with insect behavior in the secondary school biology program.

CHAPTER III

METHODS AND PROCEDURES USED IN CONDUCTING THE INQUIRY

I. METHOD OF TEACHER INTERVIEWS

On Februrary 26, 1973, a letter of intent was sent to each Superintendent of Schools in the previously mentioned school systems. This letter explained the purpose of the inquiry and requested the names of the biology teachers in the school system (Appendix II). Permission was obtained to contact each of the teachers and request their assistance. As suggested by Good (1966) and noted in the studies by Jacknicke (1968), Dyke (1970) and Anderson (1972), an interview has several advantages over a questionnaire. An interview usually provides a higher rate of response and teacher attitudes and replies can be more accurately analyzed since it is possible to clarify questions and answers. Besides, responses tend to be freer with personal contact. The size of the sample population was small enough to make the use of an interview method possible despite the geographical distances between teachers in the survey.

On April 9, 1973, each teacher was sent a letter explaining the purpose of the inquiry and requesting his assistance (Appendix III). Then at the end of the month each teacher was contacted by telephone to determine his willingness to take part in the survey and to establish the time and place of the interview. This procedure was preferred over the use of mailed replies since it was felt that there would likely be a higher rate of response with verbal contact

and the nature of the interview could be clarified if the teacher had any questions. All of the 18 teachers contacted by letter agreed to take part in the survey when contacted by telephone.

These interviews were conducted between April 30 and May 4, 1973. The sample population covered four school divisions, two districts, and one county in southwestern Alberta with a total of 12 rural and six urban secondary school biology teachers (Table I). The reasons for selecting this area were threefold: the writer was acquainted with the schools and biology of the area, the proposed projects could be implemented in school systems adjacent to the writer's place of employment, and the survey would provide information about an area not considered in previous studies and thus extend previous findings.

Furthermore, the area provided a cross-section of rural and urban teachers with varying degrees of accessibility to natural resources. The sample included both large composite secondary schools and small junior-senior high schools and both separate and public school systems. Not only does the area include a wide range of socio-economic communities such as farming, ranching, oil, mining, and lumbering, but it also covers a wide range of ecological habitats, from short-grass prairie and aspen parkland to foothills, mountain forests, and subalpine meadows. Due to this diversity in both educational and biological aspects, it was felt that the area would provide a representative survey of southwestern Alberta, particularly with a survey of the total teacher population.

TABLE I

SCHOOLS VISITED IN THE INQUIRY

SCHOOL	NUMBER OF TEACHERS INTERVIEWED
Cardston High School	1
Catholic Central High School	1
Coalhurst High School	1
Crowsnest Consolidated High School	1
F.P. Walshe High School	1
J.T. Foster High School	1
Kate Andrews High School	1
Lethbridge Collegiate Institute	3
Livingston High School	1
Magrath High School	1
Matthew Halton High School	1
Noble Central High School	1
Picture Butte High School	1
Willow Creek Composite High School	1
Winston Churchill High School	2
TOTAL	18

II. EXPLANATION OF TEACHER INTERVIEW QUESTIONS

The interview guides were numbered so that the teachers in the survey would be anonymous. Besides the date and the school, the following information was recorded to provide a brief teacher profile and to determine if any of these variables were related to the instructional procedures used by the teacher:

1. Sex of the teacher.
2. The number of full year biology, ethology, entomology, and biological methods courses taken, semestered courses being recorded as one half of a year.
3. The number of years of teaching experience.
4. The number of years of university training.
5. The year of graduation and the year last attended university to determine the most recent date of university attendance to upgrade training. If a teacher held more than one degree, the nature of each degree and the year it was granted was recorded.
6. The number of classes taught at the time of the interview, the texts used in biology classes, and the average size of biology classes.
7. The teacher's opinion of the accessibility of natural resources and any difficulties encountered by the teacher in utilizing such resources.

In addition to this information, the following questions were asked:

1. "What number of projects currently being conducted take

each of the following forms? a. individual projects b. small group projects c. entire class projects."

This question was designed for two purposes, first to determine the percentages of the total for specific projects in questions two to five; and second, to determine the extent of project use. If teachers did not conduct projects, questions two to eight inclusive and question 14 were omitted.

2. "What number of these projects deal with behavior?"

3. "What number of these projects deal with live organisms?"

4. "What number of these projects deal with live insects?"

5. "What number of these projects deal with insect behavior?"

These four questions provided information on the extent of studies in behavior and the extent of live organism utilization for comparison with earlier findings by Jacknicke (1968) and Dyke (1970).

6. "Are these projects chosen by the teacher, the pupil, or by both of these methods?"

7. "Are these projects run concurrently with the regular biology course or as a unit of time?"

8. "Approximately how many weeks of class time are spent on student projects?"

The purpose of these three questions on the nature of projects currently being conducted was twofold: to compare the results with the findings by Anderson (1972) and to establish guidelines for the construction of later projects since the method of choosing projects, the method of implementing projects, and the method of conducting projects place limitations on the types of

projects dealing with insect behavior that can be used in the classroom.

9. "How would you rank the following objectives of projects in importance? (5 very high importance, 4 high importance, 3 medium importance, 2 low importance, 1 very low importance) ...."

10. "To what extent do you feel projects dealing with insect behavior can achieve the preceding objectives? (5 very high achievement, 4 high achievement, 3 medium achievement, 2 low achievement, 1 very low achievement)"

Ten objectives were listed in these two questions and provision was made for the teacher to identify additional objectives (Appendix IV). The objectives in these two questions were those found most frequently in the literature, most of which were suggested in the current Alberta biology curriculum guide (1971) or the junior high school project guide published by the Edmonton Public School Board (1970). The projects designed later by the writer attempted to emphasize those objectives deemed most important by the teachers in the survey.

11. "To what extent do you feel the following items are advantages in conducting projects dealing with insect behavior? (5 very high advantage, 4 high advantage, 3 medium advantage, 2 low advantage, 1 very low advantage) ...."

12. "To what extent do you feel the following items are problems in conducting projects dealing with insect behavior? (5 very great problem, 4 great problem, 3

medium problem, 2 little problem, 1 very little problem) ...."

Ten possible advantages and 13 possible problems were listed and provision was made for the teacher to identify additional items (Appendix IV). These two questions were designed to determine the opinions of teachers on the use of projects dealing with insect behavior so that the proposed projects could be designed to attempt to overcome suspected problems and to emphasize goals deemed most applicable by the teachers. A list of advantages and disadvantages was used since it was felt that teachers would not consider a sufficient number of aspects in the time limited to an interview.

13. "List as specifically as possible those insects used during the school years 1969/70 to 1972/73 and indicate: a. if they were used in projects or in laboratory exercises; b. if they were purchased, collected by pupils, or collected by the teacher; c. if there were any attempts to culture the insects; d. the number of cultures maintained; e. how long the insects were used (in weeks); and f. the reason the insects were used."

14. "List those ethology projects which have been conducted during the school years 1969/70 to 1972/73 and the organisms used."

These two questions were designed to determine the extent of entomology and ethology research in the schools. The period 1969/70 to 1972/73 was selected since this is the period during which projects have been implemented in the Alberta biology program. A period of four years was covered instead of just the current year

for several reasons. First, the restriction in topics to insects and behavior would result in a small amount of data if only one year were considered. Second, the total range of usage could only be determined if the four year period was considered since if the topics are chosen by students, topics will possibly differ from year to year. Third, the extent of usage would also be more accurate since the extent, like diversity, might depend on student choices.

One disadvantage of covering a period of four years was that teachers could not recall all projects conducted over this period, even when notified of these two questions by telephone prior to the interview. A second disadvantage was that teachers were unable to identify specific species that were used for some taxonomic groups since the species had not been determined in the project or could not be recalled by the teacher. A third disadvantage was that four teachers had less than four years teaching experience. The organisms used and the projects conducted during the years these teachers did teach biology were included in the analysis of responses to these two questions. It was felt by the writer that the advantages of covering a period of four years outweighed these disadvantages although it was realized that the data obtained would be incomplete.

III. METHOD OF PROJECT CONSTRUCTION

Twelve projects dealing with insect behavior were designed between June 1 and July 31, 1973. From the data on the method of project implementation (interview questions one, six, seven, and eight), it was evident that these projects had to be adaptable to meet a wide range of instructional methodologies. An attempt was

made to include those objectives emphasized by the teacher sample in each of the projects, these main objectives being the following items: to give each student an opportunity to do an in-depth study in an area of his interest, to encourage formation of investigative questions, to practise methods of proper scientific reporting, to develop attitudes of curiosity and inquiry, and to encourage a respect and feeling for living things.

The major problems suspected by teachers in the survey received close consideration in the design of these projects. The equipment involved was limited to materials commonly found in the school or home, or which could be constructed by the student. A summary of background theory was provided in each project to overcome the lack of reference material and make each project self-contained. Collection and culturing techniques were also summarized and the exercises were selected so that each project could be conducted anywhere from one to eight weeks, depending on the depth desired by the teacher and/or the student.

The insects suggested were those involving the least amount of care and those that were the most likely to produce positive results. Furthermore, the exercises were selected to include insects commonly found in Alberta, especially those that were reported to be in use already although an attempt was made to increase the range of utilization where more appropriate insects could be used.

With these considerations, the Tertiary (third figure) Index used to classify scientific literature by the Department of Entomology, University of Alberta, was consulted. From this list,

topics were chosen to cover a representative range of behavioral topics. Over twenty exercises were finally selected from available laboratory guides, secondary school biology texts, education periodicals, and entomology research papers. These were modified for secondary school use and for continuity within each behavioral topic. This research was supplemented by examination of equipment used in the Entomology Department of the University of Alberta and consultation with personnel of the Department.

A description of the content and design of these projects was included in the materials sent to the teachers in September for implementation in the schools (Appendices VI and VII).

IV. METHOD OF PROJECT IMPLEMENTATION AND EVALUATION

On September 1, 1973, the 18 teachers in the initial survey were contacted by letter (Appendix V). They were notified that copies of 12 student guides dealing with projects on insect behavior were available. Permission was requested to interview any students using these guides upon completion of their project. Accompanying this letter were the following items:

1. Teacher Guide to Insect Behavior Projects: a summary of the philosophy, objectives, structure, and methods of implementation of the projects dealing with insect behavior. (Appendix VI)
2. Student Guide to Insect Behavior Projects: a summary of the objectives, experiments, and insects involved in each of the 12 guides. (Appendix VII)
3. The proposed Student Interview Guide designed to evaluate

the advantages and disadvantages of conducting projects dealing with insect behavior. This guide also attempted to evaluate the specific project guide used by the student. (Appendix VIII)

4. A request form and a stamped, self-addressed envelope. Specific student guides were forwarded to the two teachers who responded to this letter.

The Student Guide To Insect Behavior Projects was also posted in the writer's classroom along with other available project guides and suggestions. The writer's grade 11 and grade 12 students were given two weeks to review available literature in the library. They were then allowed to choose their own research topics within the guidelines suggested in the current Alberta curriculum guide for biology (1971).

To ensure that students had given forethought to the selection of their topics, a Project Selection form based on the recommendations made by the Edmonton Public School Board (1970), Thurber and Collette (1965), Richardson and Cahoon (1951), and Ricard (1965) was used (Appendix IX). By using this form, students were made aware of possible problem areas in their research. Furthermore, the writer was able to ensure that the students understood the objectives of the project method, and that they had a definite outline of research before beginning the project. It was found that fewer students changed topics later in the semester in comparison with previous years when such a form was not used.

On November 26, 1973, teacher guides for the four specific projects which had been selected were mailed to the respective

teachers. At this time the two teachers were asked to arrange for appointments at their convenience so that the students involved could be interviewed. The teachers were also requested to prepare their students for the interview by asking the students to begin thinking of the advantages and the disadvantages of the specific guides that were used. The writer's students were given the same instructions November 29, 1973. The 14 students who had conducted projects on insect behavior were interviewed by the writer between December 14 and December 20, 1973.

V. EXPLANATION OF STUDENT INTERVIEW QUESTIONS

The student interview guides were numbered so that the students in the survey would be anonymous. In addition to the name of the guide and the insects used in the project, the students were asked the following questions:

1. "To what extent do you feel the following items are advantages in conducting projects dealing with insect behavior? (5 very high advantage, 4 high advantage, 3 medium advantage, 2 low advantage, 1 very low advantage) ...."

Seven items were listed and provision was made for the student to identify additional advantages (Appendix VIII). The purpose of this question was to obtain the student's opinions on the value of projects dealing with insect behavior. It seemed reasonable to assume that the student's responses would also have reflected his opinion of the advantages of the specific project he had completed.

2. "To what extent did you find the following items were problems in conducting your project on insect behavior? (5 very great problem, 4 great problem, 3 medium problem, 2 little problem, 1 very little problem) ...."

Fourteen items were listed and provision was made for the student to identify additional problems he had encountered (Appendix VIII). The purpose of this question was twofold: to determine the practicality of conducting projects on insect behavior and to evaluate the success of the guides in overcoming possible problems suggested in the literature.

3. "The project guide you used contained the following nine sections. Indicate in the first column which aspects were helpful to you and how they were helpful. Indicate in the second column how the guide might be changed to be more helpful."

The nine sections listed covered the content of each student guide (Appendix VIII). The purpose of this question was to evaluate the specific guide that was used so that recommendations on the construction of student guides could be made. This question also provided further insight into the advantages and disadvantages of conducting projects on insect behavior since during the interview the student stressed what he had derived from the project and what difficulties he had encountered.

VI. SUMMARY OF PROCEDURES AND METHODS

On February 26, 1973, a letter of intent was sent to the Superintendents of Schools in seven school systems in southwestern

Alberta. Permission to contact the secondary school biology teachers in those areas was obtained and on April 9, 1973, each teacher was sent a letter explaining the purpose of the inquiry and requesting his assistance. At the end of the month appointments were made with the teachers by telephone. Interviews with the 18 teachers were conducted between April 30 and May 4, 1973, to determine the extent and nature of project implementation, the extent to which live organisms were being used in the study of behavior, and the opinions of the teachers on the use of projects dealing with insect behavior.

This information, supplemented by recommendations from the available literature and examination of equipment used by the Department of Entomology at the University of Alberta, was used to devise 12 projects dealing with insect behavior. These projects were devised between June 1 and July 31, 1973, and an attempt was made to cover each of the major aspects of insect behavior as listed in the three figure index used by the Department of Entomology. These guides are summarized in Appendices VI and VII.

On September 1, 1973, a summary of these guides was sent to the teachers interviewed earlier in the year and copies of specific student guides were forwarded to the two teachers requesting them. The writer's students in grades 11 and 12 were also given a summary of the guides and copies of specific project guides were provided upon the student's request. Between October 1 and November 26, 1973, teacher guides to accompany the student projects were devised from available literature and the writer's previous experiments with insects.

On November 26, 1973, the two teachers requesting guides were again contacted to arrange for interviews, and between December 14 and December 20, 1973, the 14 students who had conducted projects on insect behavior were interviewed. The purposes of this interview were to determine the student's opinions on the advantages of conducting such projects, to determine the problems encountered by these students, and to evaluate the effectiveness of the student guides which had been used.

CHAPTER IV

ANALYSIS OF TEACHER INTERVIEW DATA

I. TEACHER PROFILE

Since only two out of the 18 teachers surveyed in south-western Alberta were female, no attempt was made to determine a correlation between this variable and the content or method of conducting projects. Similarly, no conclusions could be drawn from the number of ethology courses a teacher had taken since only two teachers were involved. Both of these teachers reported that students were conducting projects dealing with behavior but neither reported projects dealing with insect behavior.

No significant differences in the content or method of conducting projects could be found between teachers having entomology courses in their background and teachers lacking such background. It would appear that having taken an entomology course did not bias a teacher towards the use of insects in projects. No differences in the content or method of conducting projects could be found in relation to recency of university training nor in the textbooks used. However, considerable unity was found in the choice of textbook, 16 teachers using the BSCS Green Version (1968), one the BSCS Yellow Version (1968), and one Otto and Towle (1965) in Biology 10; 11 teachers using the BSCS Yellow Version, five the BSCS Green Version, and one Otto and Towle in Biology 20; and five teachers using Weisz (1963) besides McElroy _et. al._ (1968) in Biology 30. The teacher profile for these variables is presented

in Appendix X.

Course Background

A relationship appeared to exist between the number of biology methods courses taken and the incidence of projects dealing with behavior, insects, and insect behavior (Table II). The percentage of teachers reporting that these three types of projects were being conducted by students increased with a corresponding increase in the number of methods courses taken.

A similar but less marked trend was also found when comparing the number of university biology courses taken and the proportion of teachers reporting that students were conducting projects dealing with behavior in their classes. Sixty percent of those teachers having taken from zero to four biology courses indicated that classroom behavior projects were being conducted. In contrast, 100% of those teachers having taken nine or more biology courses reported that classroom behavior projects were being conducted.

Teaching Experience

A low correlation appeared to exist between the number of years of teaching experience and the incidence of projects dealing with behavior, 100% of the teachers with one to three years experience reporting such projects in contrast to only 33% of the teachers having over 21 years experience. Similarly, out of the five teachers reporting 100% of their Biology 20 projects dealt with live organisms, four had from one to three years experience. Conversely, out of the four teachers reporting none of their Biology 10 projects dealt with live organisms, three had 16 or more

TABLE II

TEACHER PROFILE AND PROJECT TOPIC

VARIABLE		NO. OF TEACH.	USED BEHAVIOR PROJECTS				USED INSECT PROJECTS				USED INSECT BEHAVIOR PROJECTS			
			YES		NO		YES		NO		YES		NO	
			NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
No. of	0	3	0	0	3	100	0	0	3	100	0	0	3	100
Biology	1	10	9	90	1	10	3	30	7	70	1	10	9	90
Methods	+1	4	4	100	0	0	3	75	1	25	2	50	2	50
No. of	0-4	5	3	60	2	40	0	0	5	100	0	0	5	100
Biology	5-8	7	5	71	2	29	4	57	3	43	2	29	5	71
Courses	9+	5	5	100	0	0	2	40	3	60	1	20	4	80
Years	1- 3	5	5	100	0	0	2	40	3	60	0	0	5	100
of	4- 7	4	3	75	1	25	0	0	4	100	0	0	4	100
Teach.	8-16	5	4	80	1	20	3	60	2	40	2	40	3	60
Exper.	21-28	3	1	33	2	67	1	33	2	67	1	33	2	67
Years of	-5	8	8	100	0	0	3	37	5	63	2	25	6	75
Univ.	5	6	3	50	3	50	2	33	4	67	0	0	6	100
Training	6+	3	2	67	1	33	1	33	2	67	1	33	2	67
Year	-1960	5	2	40	3	60	1	20	4	80	3	60	2	40
of	61-68	6	6	100	0	0	2	33	4	67	2	33	4	67
Grad.*	1969+	5	4	80	1	20	3	60	2	40	0	0	5	100
No. of	4-5	4	2	50	2	50	1	25	3	75	1	25	3	75
Classes	6	7	5	71	2	29	3	43	4	57	1	14	6	86
	7+	6	6	100	0	0	2	33	4	67	1	17	5	83
Class	16-21	7	6	86	1	14	3	43	4	57	1	14	6	86
Size	22-25	5	5	100	0	0	2	40	3	60	3	60	2	40
	26-30	5	2	40	3	60	1	20	4	80	0	0	5	100
Accessi-	Ex	13	11	85	2	15	5	38	8	62	3	23	10	77
bility**	VG	4	2	50	2	50	1	25	3	75	0	0	4	100

* Year Bachelor of Education Degree was granted. One teacher with less than four years of training excluded.

** Ex: excellent; VG: very good

years experience.

A relationship also appeared to exist between the number of years of teaching experience and the amount of class time devoted towards projects (Table III). Teachers having from one to seven years of experience reported both extremes (zero weeks and six weeks) whereas more experienced teachers having eight to 28 years of experience tended to be more moderate, the majority devoting three to four weeks of class time towards projects.

<u>University Training</u>

There also appeared to be a relationship between the number of years of university training and the incidence of projects dealing with behavior in this inquiry. With the exception of one teacher having three and one half years of university training, all teachers surveyed had at least four years of university training and one degree. Ten of the 18 teachers had two degrees. Of the eight teachers having less than five years training, 100% reported the use of projects dealing with behavior. The incongruity between this relationship and the relationship noted for the number of university biology courses taken would appear to indicate further research is required for these two variables.

Although not as distinct as for teaching experience, a similar relationship appeared to exist between the number of years of university training and the amount of class time spent on projects, those teachers with more training again devoting three to four weeks of class time.

A relationship was also found between the year of graduation

TABLE III

TEACHER PROFILE AND PROJECT IMPLEMENTATION

VARIABLE		NO. OF TEACH.	METHOD OF CHOICE				WEEKS OF CLASS TIME SPENT							
			PUPIL		PUPIL & TEACHER		0		1-2		3-4		5-6	
			NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
No. of	0	3	3	100	0	0	0	0	1	33	1	33	1	33
Biology	1	10	7	70	3	30	0	0	4	40	4	40	2	20
Methods	+1	4	2	50	2	50	2	50	0	0	2	50	0	0
No. of	0-4	5	5	100	0	0	0	0	1	20	2	40	2	40
Biology	5-8	7	4	57	3	43	0	0	3	43	3	43	1	14
Courses	9+	5	3	60	2	40	2	40	1	20	2	40	0	0
Years	1- 3	5	5	100	0	0	1	20	2	40	1	20	1	20
of	4- 7	4	2	50	2	50	1	25	1	25	0	0	2	50
Teach.	8-16	5	2	40	3	60	0	0	1	20	4	80	0	0
Exper.	21-28	3	3	100	0	0	0	0	1	33	2	67	0	0
Years of	-5	8	5	63	3	37	1	13	3	37	3	37	1	13
Univ.	5	6	5	83	1	17	1	17	2	33	1	17	2	33
Training	6+	3	2	67	1	33	0	0	0	0	3	100	0	0
Year	-1960	5	3	60	2	40	0	0	1	20	4	80	0	0
of	61-68	6	6	100	0	0	1	17	3	50	1	17	1	17
Grad.*	1969+	5	2	40	3	60	1	20	1	20	1	20	2	40
No. of	4-5	4	2	50	2	50	0	0	0	0	2	50	2	50
Classes	6	7	6	86	1	14	1	14	3	43	3	43	0	0
	7+	6	4	67	2	33	1	17	2	33	2	33	1	17
Class	16-21	7	4	57	3	43	1	14	3	43	3	43	0	0
Size	22-25	5	3	60	2	40	0	0	0	0	3	60	2	40
	26-30	5	5	100	0	0	1	20	2	40	1	20	1	20
Accessi-	Ex	13	10	77	3	23	1	8	3	23	6	46	3	23
bility**	VG	4	2	50	2	50	1	25	2	50	1	25	0	0

* Year Bachelor of Education Degree was granted. One teacher with less than four years of training excluded.

** Ex: Excellent; VG: Very Good

and the use of insect projects in this inquiry. Twenty percent of those teachers receiving their Bachelor of Education degree before 1960 reported classroom projects involving insects compared with 60% of those receiving their degree since 1969. However, no corresponding relationship could be found for the related aspects of project content such as the incidence of projects dealing with behavior, the incidence of projects dealing with insect behavior, and the use of live organisms. This incongruity may possibly be due to the small sample size in this inquiry.

The year of graduation appeared to be related to the amount of class time spent on projects. This was in agreement with the relationship of this aspect to both years of teaching experience and years of university training. Twenty percent of the graduates since 1969 devoted no class time towards projects and 40% devoted five to six weeks of class time towards projects. On the other hand, no graduates before 1960 reported these two extremes and 80% devoted three to four weeks of class time to project work.

Number and Size of Classes

The number of classes taught might be related to the use of projects dealing with behavior, 50% of those teachers teaching four to five classes having used projects dealing with behavior in contrast to 100% of those teachers having seven or more classes. Conversely, with respect to class size, the incidence of projects dealing with behavior was higher in smaller classes (Table II).

A similar relationship might exist between class size and the use of insects. Forty-three percent of the teachers having 16

to 21 pupils per class reported using insects compared to 20% of those teachers having 26 to 30 pupils per class. Class size might also influence the method of choosing projects. One hundred percent of those teachers with 26 to 30 pupils per class left the choice of a project topic up to the pupil whereas only 57% of those teachers with 16 to 21 pupils per class used this method exclusively.

Accessibility

All teachers reported accessibility of natural resources as excellent and without restrictions (13 teachers) or very good within certain limitations (four teachers). These limitations were the lack of diversity in accessible habitats and difficulties in arranging field trips due to conflicts with other classes, lack of transportation, or large class sizes. Due to the similarity between these two assessments of resource accessibility, only slight differences were found between the two groups with respect to the use of projects dealing with behavior, insects, and insect behavior (Table II). In all three aspects a larger percentage of teachers in the group describing accessibility as excellent reported the investigation of such topics than in the group of teachers describing accessibility as having limitations.

Rural/Urban Differences

Dividing the teacher sample into rural and urban teachers, a relationship appeared to exist between this variable and the study of behavior, insects, and insect behavior in this survey (Table IV). A larger percentage of the rural sample reported the election of these three types of projects. Differences also existed in the

TABLE IV

RURAL/URBAN COMPARISON OF TEACHERS

PROJECT ASPECT		TEACHERS* RURAL NO.	RURAL %	URBAN NO.	URBAN %
USED BEHAVIOR PROJECTS	Yes	10	83	3	60
	No	2	17	2	40
USED INSECT PROJECTS	Yes	5	42	1	20
	No	7	58	4	80
USED INSECT BEHAVIOR PROJECTS	Yes	3	25	0	0
	No	9	75	5	100
METHOD OF CHOICE	Pupil	9	75	3	60
	Pupil and Teacher	3	25	2	40
WEEKS OF CLASS TIME SPENT	0	1	8	1	20
	1 - 2	4	33	1	20
	3 - 4	6	50	1	20
	5 - 6	1	8	2	40
USED PROJECTS IN BIOLOGY	10	12	100	4	67
	20	11	92	3	60
	30	12	100	4	80
METHOD OF IMPLEMENTATION	Concurrent	11	92	4	80
	Unit	1	8	0	0
	Both	0	0	1	20

* Population Totals: 12 Rural, 5 Urban for each aspect except Biology 10 Projects (12 Rural, 6 Urban)

method of conducting projects. A greater percentage of rural teachers was found to rely on pupil choice of topics in the election of projects. No urban teachers were found to rely exclusively on the unit method of implementing projects.

One of the six urban teachers did not use the project method. In Table IV this teacher has only been included in the item "USED PROJECTS IN BIOLOGY". Since one urban teacher did not teach Biology 20 or 30, the urban population totals for this item were six Biology 10 teachers, five Biology 20 teachers, and five Biology 30 teachers. Of the urban population, 66.7% of the teachers used the project method in Biology 10, 60% used the project method in Biology 20, and 80% used the project method in Biology 30. The percentages of rural teachers using the project method were 100%, 91.7%, and 100% respectively.

II. PROJECT IMPLEMENTATION

As shown in Table V, the most common form projects took in each grade was a combination of individual and group projects. The only other form commonly used was individual projects in Biology 30. Teachers offered two reasons for this change in procedures: classes were smaller and thus teacher time and equipment were available for each student, or, students had practice in project work in prior biology courses and were encouraged to attempt individual research in Biology 30.

Only one teacher did not conduct projects in any of the three grades taught. This teacher indicated dissatisfaction with student performance on projects and substituted laboratory exercises

TABLE V

FORM OF PROJECTS IMPLEMENTED

TYPE OF PROJECT	NUMBER OF TEACHERS BIOLOGY 10	BIOLOGY 20	BIOLOGY 30	ALL 3 COURSES *
Individual Only	1	2	4	1
Group Only	2	2	1	0
Class Only	0	0	1	0
Individual and Group	11	8	6	9
Individual and Class	1	2	2	1
Individual, Group and Class	1	0	2	3
No Projects Conducted	2	3	1	*
TOTAL NUMBER OF TEACHERS	18	17	17	14

* Only those teachers conducting projects in all three courses have been included in this column.

for this portion of the course. A second teacher conducted projects only in Biology 30 due to large class enrolments, resulting in a lack of teacher time and laboratory facilities as well as a heavy teaching load. A third teacher conducted projects in Biology 10 and Biology 30 but not in Biology 20. This teacher indicated two factors hindering project implementation: Biology 10 and Biology 20 classes were conducted for only one half a semester, making long-term projects impossible, and the school lacked a laboratory. One teacher was teaching only Biology 10 as a temporary instructor due to large biology enrolments. In analyzing the procedures used in all biology courses taught by each teacher, these four teachers were excluded. Of the 14 teachers conducting projects in all three courses, nine (64.3%) used a combination of individual and group projects and three (21.4%) used all three methods in their teaching.

None of the teachers conducting projects relied exclusively on teacher choice in implementing projects (Table VI). The majority of the teachers in each grade allowed the student to choose the topic (68.7% of the Biology 10 teachers, 71.4% of the Biology 20 teachers, and 68.7% of the Biology 30 teachers). The use of both methods occurred if a student was unable to decide on a topic, if a student procrastinated, or if class projects were being used.

Only two teachers conducted projects as a unit of time. One used this method exclusively in all three grades. The other teacher conducted group projects concurrently with the course in all three grades but in addition conducted individual projects in Biology 10 as a unit before allowing pupils to work on group projects.

TABLE VI

PROJECT METHODOLOGY

PROJECT ASPECT		NUMBER OF TEACHERS BIOLOGY 10	BIOLOGY 20	BIOLOGY 30
METHOD	Teacher	0	0	0
OF	Pupil	11	10	11
CHOICE	Both	5	4	5
TOTAL		16	14	16
METHOD	Concurrent	14	13	15
OF	Unit	1	1	1
IMPLEMENTATION	Both	1	0	0
TOTAL		16	14	16

The amount of class time spent on student projects ranged from no class time to eight weeks (Table VII). Nine teachers (53%) devoted the same amount of class time in each grade taught and four teachers (23%) varied the time according to the grade. The ratios used by these four teachers for Biology 10, 20, and 30 respectively were two, four, and five weeks; six, four, and eight weeks; four, four, and seven weeks; and three, three, and six weeks. Two teachers devoted no class time towards projects and two teachers had projects only in one grade. Computing the average amount of class time devoted by each teacher for all biology classes in which projects were conducted, the most frequent responses were one week (29% of the 17 teachers), four weeks (23%), and three weeks (18%).

Teachers volunteered the following reasons for devoting no or little class time towards projects: time was needed to cover course content, coverage of course content was more important than project work, students wasted time when class time was given, projects were treated as assignments, projects involved field research or were of such a nature that they could not be conducted in the school, and class periods were too short for projects to be conducted efficiently.

III. TEACHER OPINIONS ON PROJECTS

A five-point Likert scale was used to grade items on the following four topics: the importance of project objectives, the achievement of these objectives by projects dealing with insect behavior, the advantages of using projects dealing with insect behavior, and the disadvantages of using projects dealing with

TABLE VII

CLASS TIME SPENT ON PROJECTS

NUMBER OF WEEKS	NUMBER OF TEACHERS BIOLOGY 10	BIOLOGY 20	BIOLOGY 30	NUMBER OF TEACHERS* TOTAL SAMPLE	RURAL TEACHERS	URBAN TEACHERS
0	2	2	2	2	1	1
1	5	4	5	5	4	1
2	1	0	0	0	0	0
3	2	2	2	3	2	1
4	4	6	3	4	4	0
5	0	0	1	1	1	0
6	2	0	1	2	0	2
7	0	0	1	0	0	0
8	0	0	1	0	0	0
TOTAL NUMBER OF TEACHERS	16	14	16	17	12	5

* The average amount of class time devoted towards projects by each teacher was determined by totalling the amount of class time spent in each course and dividing by the number of courses taught.

insect behavior. Teacher responses were then ranked according to the total number of teachers that indicated the item was of high importance or very high importance. The sum of these two columns was used in an attempt to overcome errors of leniency and central tendency commonly found on questions asking the respondent to rank items as noted by Helmstadter (1970).

The most important project objectives according to this survey were the following items: to develop and encourage attitudes of curiosity and inquiry (88.9% of the 18 teachers indicating that this objective was high or very high in importance), to give each student an opportunity to do an in-depth study in an area of his interest (83.7%), and to encourage a respect and feeling for living things (72.2%). Teachers indicated that objectives of least importance were the following items: to permit the development of empathy with the scientific researcher (only 33.3% of the teachers indicating that this objective was high or very high in importance), to allow students to evaluate the work of peers (27.8%), and to evaluate the effect of scientific discoveries (27.8%).

Four teachers each suggested one additional objective besides those in Table VIII. These objectives were "to provide for student initiative", "to provide student motivation", "to develop initiative in individual study", and "to relate biological theory to practice".

Three teachers found it difficult to assess the achievement of these objectives by projects dealing with insect behavior due to a lack of familiarity with such projects. As a result, the total population for this aspect was 15 teachers (Table IX). The

TABLE VIII

IMPORTANCE OF PROJECT OBJECTIVES

OBJECTIVE	NUMBER OF TEACHERS INDICATING IMPORTANCE 1 VERY LOW	2 LOW	3 MEDIUM	4 HIGH	5 VERY HIGH	TOTAL (ITEMS 4 + 5)	RANK
a. To give each student an opportunity to do an in-depth study in an area of his interest	0	1	2	7	8	15	2
b. To encourage students to formulate questions for investigative purposes	0	1	5	5	7	12	4.5
c. To further familiarize students with research methods	0	1	5	8	4	12	4.5
d. To enable students to practise methods of proper scientific reporting	0	1	6	5	6	11	6
e. To permit the development of empathy with the scientific researcher	0	4	8	4	2	6	8
f. To develop and encourage attitudes of curiosity and inquiry	0	0	2	8	8	16	1
g. To encourage a respect and feeling for living things	0	1	4	3	10	13	3
h. To provide material supplemental to the course	1	3	5	6	3	9	7
i. To evaluate the effect of scientific discoveries	1	5	7	4	1	5	9.5
j. To allow students to evaluate work of peers	4	3	6	4	1	5	9.5

TABLE IX

ACHIEVEMENT OF OBJECTIVES BY PROJECTS DEALING WITH INSECT BEHAVIOR

OBJECTIVE	NUMBER OF TEACHERS INDICATING ACHIEVEMENT 1 VERY LOW	2 LOW	3 MEDIUM	4 HIGH	5 VERY HIGH	TOTAL (ITEMS 4 + 5)	RANK
a. To give each student an opportunity to do an in-depth study in an area of his interest	0	2	6	3	4	7	7
b. To encourage students to formulate questions for investigative purposes	0	0	6	4	5	9	5
c. To further familiarize students with research methods	0	0	5	6	4	10	3.5
d. To enable students to practise methods of proper scientific reporting	0	0	4	4	7	11	1.5
e. To permit the development of empathy with the scientific researcher	1	1	6	5	2	7	7
f. To develop and encourage attitudes of curiosity and inquiry	0	0	4	4	7	11	1.5
g. To encourage a respect and feeling for living things	0	3	2	4	6	10	3.5
h. To provide material supplemental to the course	1	2	5	3	4	7	7
i. To evaluate the effect of scientific discoveries	0	4	7	3	1	4	10
j. To allow students to evaluate work of peers	2	2	5	4	2	6	9

objectives that teachers felt would most likely be achieved were the following items: to develop and encourage attitudes of curiosity and inquiry (73.3% of the teachers indicating high or very high achievement), to enable students to practise methods of proper scientific reporting (73.3%), to encourage a respect and feeling for living things (66.7%), and to further familiarize students with research methods (66.7%). Objectives least likely to be achieved according to this survey were the items "to allow students to evaluate the work of peers" (only 40.0% of the teachers indicating high or very high achievement), and "to evaluate the effect of scientific discoveries" (26.7%).

Over 50% of the teachers surveyed felt each advantage of projects dealing with insect behavior suggested was of high or very high importance with the exception of the item "stimulation of further research". Only 44.4% of the teachers felt that this was a high or very high advantage. The major advantages of projects dealing with insect behavior seen by these teachers were the following items: development of skill in scientific thinking and problem-solving (88.9%), provision for active student involvement (87.7%), illustration of biological principles (77.8%), and provision for individualized instruction (72.2%).

Objectives of least importance besides stimulation of further research were the items "development of techniques in using laboratory equipment (only 50% of the teachers indicating high or very high advantage), and "development of an appreciation for living organisms" (61.1%). Only one teacher offered an additional advantage, that being to provide research opportunities in the field.

TABLE X

ADVANTAGES OF PROJECTS DEALING WITH INSECT BEHAVIOR

ADVANTAGE	NUMBER OF TEACHERS INDICATING ADVANTAGE 1 VERY LOW	2 LOW	3 MEDIUM	4 HIGH	5 VERY HIGH	TOTAL (ITEMS 4 + 5)	RANK
a. Stimulates interest and motivation	0	0	6	5	7	12	6
b. Provides for individualized instruction	0	0	5	8	5	13	4
c. Stimulates further research	0	1	9	4	4	8	10
d. Develops an appreciation for living organisms	0	1	6	6	5	11	8
e. Provides for active involvement	0	0	3	6	9	15	2
f. Can be used to illustrate biological principles	0	1	3	5	9	14	3
g. Develops skill in scientific thinking and problem-solving	0	0	2	11	5	16	1
h. Develops scientific attitudes	0	0	6	6	6	12	6
i. Provides student with content of special interest	0	0	6	6	6	12	6
j. Develops techniques in using laboratory equipment	0	0	9	3	6	9	9

Four main problems were indicated by teachers in this sample. These were the following items: lack of proper equipment (61.1% of the teachers indicating this was a great or very great problem), lack of adequate reference material (50%), too time consuming (50%), and insufficient teacher background in collecting and culturing techniques (50%). The least important problems according to this survey were the following items: lack of adequate space (only 27.8% of the teachers indicating this was a great or very great problem), difficulty in culturing insects (27.8%), and difficulty in handling insects (16.7%). Two other problems suggested were lack of assistance available to the teacher and unavailability of insects when they are needed.

IV. PROJECT CONTENT

Live Organisms

Seventeen out of the 18 teachers (94.4%) used live organisms in their teaching, 15 teachers (83.3%) using only feral organisms or feral organisms in addition to commercial organisms. Sixteen of the 17 teachers using projects (94.1%) reported the use of live organisms in student projects. The one teacher who did not use live organisms in projects nor in his teaching had no biology or biology methods background and was teaching only Biology 10 as a temporary instructor due to large biology enrolments.

As indicated in Table XII, the proportion of projects involving live organisms varied considerably between teachers for each grade. However, 63% of the Biology 10 teachers indicated that at least half of the projects being conducted involved live

TABLE XI

PROBLEMS IN CONDUCTING PROJECTS DEALING WITH INSECT BEHAVIOR

PROBLEM	NUMBER OF TEACHERS INDICATING PROBLEM 1 VERY LITTLE	2 LITTLE	3 ME-DIUM	4 GREAT	5 VERY GREAT	TOTAL (ITEMS 4 + 5)	RANK
a. Lack of proper equipment	2	1	4	5	6	11	1
b. Lack of adequate space	3	3	7	1	4	5	11.5
c. Lack of adequate reference material	1	3	5	5	4	9	3
d. Student lacks sufficient biological background	0	3	7	5	3	8	6.5
e. Classes are too large	0	4	6	5	3	8	6.5
f. Lack of student interest	1	3	6	5	3	8	6.5
g. Too time consuming	1	4	4	5	4	9	3
h. Insufficient teacher background in collecting and culturing techniques	1	4	4	5	4	9	3
i. Inadequate knowledge of what insects are available	1	6	4	4	3	7	9.5
j. Adequate insects are unavailable the year round	0	2	8	4	4	8	6.5
k. Insects are too difficult to handle in experiments	2	5	8	2	1	3	13
l. Insects are too difficult to culture	2	3	8	5	0	5	11.5
m. Insects are too difficult to maintain over holidays	1	6	4	6	1	7	9.5

TABLE XII

USE OF LIVE ORGANISMS IN PROJECTS

PERCENTAGE OF TOTAL PROJECTS CONDUCTED	NUMBER OF TEACHERS BIOLOGY 10	BIOLOGY 20	BIOLOGY 30	ALL 3 COURSES*
0 %	4	0	2	0
1 - 10	1	1	1	1
11 - 20	0	0	0	0
21 - 30	1	0	1	1
31 - 40	0	0	2	0
41 - 50	0	3	1	1
51 - 60	1	2	1	4
61 - 70	1	0	1	2
71 - 80	3	2	2	2
81 - 90	3	1	0	0
91 - 99	0	0	1	2
100	2	5	4	1
TOTAL NUMBER OF TEACHERS	16	14	16	14

* Only those teachers conducting projects in all three courses have been included in this item. The average percentage of total projects was determined by totalling the percentage for each course and dividing by the number of courses taught.

organisms, compared with 71% of the Biology 20 teachers and 56% of the Biology 30 teachers. In computing the average for all three courses, four teachers had to be excluded as explained on page 55 resulting in a population total of 14. Eleven of these teachers (78.6%) indicated at least half of the projects being conducted involved live organisms.

Insects

Current Utilization

Although 94.4% of the teachers surveyed were currently using live organisms, only 33.3% (six teachers) reported current use of insects. Of those teachers conducting projects in all three grades, 42.9% (six teachers) reported projects involving live insects, the proportion of all projects being conducted ranging from one to 25 percent (Table XIII). One teacher indicated 70% of the Biology 20 projects currently being conducted involved insects, the majority of these being studies in genetics with *Drosophila*.

Past Utilization

In contrast to the relatively low incidence of current insect utilization, the percentage of teachers reporting the utilization of insects between 1969 and 1973 was found to be considerably higher (Table XIV). Fifteen of the 18 teachers (83.4%) reported the use of insects over this period, all using only feral insects or feral insects in addition to commercial insects. From one to eight insects were reported by each teacher, most of the teachers reporting two insects in addition to *Drosophila*.

TABLE XIII

USE OF LIVE INSECTS IN PROJECTS

PERCENTAGE OF TOTAL PROJECTS CONDUCTED	NUMBER OF TEACHERS BIOLOGY 10	BIOLOGY 20	BIOLOGY 30	ALL 3 COURSES*
0 %	12	9	14	8
1 - 5	1	3	1	4
6 - 10	2	0	1	0
11 - 25	1	1	0	2
over 25	0	1	0	0
TOTAL NUMBER OF TEACHERS	16	14	16	14

* Only those teachers conducting projects in all three courses have been included in this item. The average percentage of total projects was determined by totalling the percentage for each course and dividing by the number of courses taught.

TABLE XIV

LIVE INSECTS USED, 1969 - 1973
REFERENCES

a 18 respondents, two with one year experience, one with two years experience, and one with one year experience in Biology 20 and Biology 30. Numerals indicate the number of teachers reporting each aspect of insect utilization.

b Where a culture attempt is indicated, followed by a zero, the attempt failed.

c Invaded the school and utilized.

d Student continued on into Entomology.

e One project won the Lethbridge District Science Fair.

f Length of use unknown.

TABLE XIV

LIVE INSECTS USED, 1969 - 1973[a]

ORGANISM		USE				SOURCE					CULTURE (b)		LENGTH OF USE							
	No. Teach. Using	Projects	Laboratory	Project and Lab.	Field Trips	Purchased	Pupil Collected	Teach. Collected	Pup. and Teach.	Purch. and Coll.	No. of Teach.	Average Size	Immediate	1-2 weeks	3-4 weeks	5-8 weeks	10-12 weeks	18 weeks	24 weeks	36 weeks
ORTHOPTERA																				
Grasshopper	5	3	1	1		1	4				1	0		2	1	2				
HEMIPTERA																				
Scale Insect	1	1						c			1	1		1						
Water Strider	1				1		1						1							
Giant Water Bug	1	1					1				1	0		1						
LEPIDOPTERA																				
Tent Caterpillar	1	1					1							1						
Moths	1	1					1							1						
Butterfly (d)	2	2					2							2						
Hawk Moth	1	1					1				1	1			1					
DIPTERA																				
Drosophila (e)	11	6	2	3		11					11	10			2	2	2	4	1	
Blowfly	1	1					1				1	1					f			
Housefly	5	5					5				4	2		1	2	1		1		
Sheep Ked	1		1					1						1						
Mosquito	1	1					1							1						
HYMENOPTERA																				
Ant	5	5					5				5	1			2	2	1			
Bee	1	1					1								1					
COLEOPTERA																				
General	1	1					1								1					
Mealworm	4	3		1		3	1				3	1		2	1					1
Potato Beetle	1	1					1									1				
Ladybird Beetle	1	1					1							1						
Water Beetle	1				1		1						1							
GENERAL COLLECTION	6	5			1		4		1	1	1	1	5				f			
AQUATIC COLLECTION	5	3			2		4		1		2	3	1		1		f			

The six insects used most frequently were Drosophila (reported by 11 teachers), grasshoppers (five teachers), houseflies (five teachers), ants (five teachers), mealworms (four teachers), and butterflies (two teachers). Six teachers reported the use of general collections and five teachers reported the use of aquatic collections for general observations. Of the six orders reported, the Diptera and the Coleoptera contained the greatest diversity of species used.

The majority of these insects were used in projects, only the sheep ked being used exclusively in laboratory exercises and only the water strider and water beetle being used in connection with field trips. Besides Drosophila, teachers purchased grasshoppers and mealworms. Teachers were actively involved in the collection of insects in only two cases. The remainder of the insects were collected by the pupils except for the scale insect which invaded the school and was subsequently utilized in a student project. The sources of the insects in the 57 cases of insect utilization were thus 67.5% pupil collected, 27.2% purchased, 3.5% teacher collected, and 1.8% invasion.

All 15 teachers reporting the use of insects also reported that the insects were cultured, but only nine teachers (60%) reported the culturing of feral species. The most frequently cultured were Drosophila (reported by 11 teachers), ants (five teachers), houseflies (four teachers), and mealworms (three teachers). Attempts at culturing the remaining insects were reported by only one teacher for each species. These insects were grasshoppers, scale insects, giant water bugs, hawk moths, and

blowflies. Two teachers also reported the maintenance of aquatic collections and one teacher reported the maintenance of a general insect collection. An average of 10 Drosophila cultures were maintained in each project whereas usually only one culture was maintained for each feral insect. Two attempts at culturing failed, these being projects using grasshoppers and giant water bugs.

The majority of the insects were used for periods of one to four weeks (45.6% of all cases reported). The Drosophila, ants, and houseflies were the only insects maintained for one semester, and the mealworm was the only insect maintained for an entire year. Of the 57 reports of insect utilization, 14.0% of the insects were used immediately, 24.6% were used for one to two weeks, 21.0% were used for three to four weeks, 14.0% were used for five to eight weeks, 5.2% were used for 10 to 12 weeks, 8.8% were used for 18 weeks, 1.8% were used for 24 weeks, and 1.8% were used for 36 weeks. The remaining 8.8% of the cases reported were used for unknown lengths of time.

Behavior

Current Investigation

Thirteen of the 18 teachers surveyed (72.2%) reported that exercises involving the study of behavior were currently being used as part of their teaching program. Thirteen of the 17 teachers using the project method (76.5%) indicated that students were currently conducting behavior projects. However, the percentage of projects currently being conducted that dealt with behavior varied considerably from teacher to teacher in each grade (Table XV). Less

TABLE XV

PERCENTAGE OF PROJECTS ON BEHAVIOR

PERCENTAGE OF TOTAL PROJECTS CONDUCTED	NUMBER OF TEACHERS BIOLOGY 10	BIOLOGY 20	BIOLOGY 30	ALL 3 COURSES*
0 %	6	3	4	1
1 - 10	2	4	4	4
11 - 20	5	1	1	3
21 - 30	0	2	3	1
31 - 40	1	0	0	3
41 - 50	2	2	2	1
51 - 60	0	0	1	0
61 - 70	0	0	0	1
71 - 80	0	1	1	0
81 - 90	0	1	0	0
TOTAL NUMBER OF TEACHERS	16	14	16	14

* Only those teachers conducting projects in all three courses have been included in this item. The average percentage of total projects was determined by totalling the percentage for each course and dividing by the number of courses taught.

than half the projects conducted in Biology 10 dealt with behavior and only 14% of the Biology 20 teachers and 13% of the Biology 30 teachers reported that the proportion of projects dealing with behavior was over 50%.

Again, in computing the average for all three courses, four teachers had to be excluded as explained on page 55, resulting in a population total of 14 teachers. The most frequent percentages of total projects conducted were from one percent to 10% (reported by 29% of the teachers), from 11% to 20% (21% of the teachers), and from 31% to 40% (21% of the teachers) despite the overall range from zero percent to 90% indicated in the table.

Only three teachers reported that projects involving insect behavior were currently being conducted at the time of the survey. One teacher reported that students were studying feeding behavior of tent caterpillars in Biology 20 and that students were studying responses of grasshoppers to chemical stimuli in Biology 30. A second teacher reported one project on general behavior of blowflies and one project on the general behavior of houseflies, both projects being in Biology 20. A third teacher reported one project on general behavior of mealworms being conducted in Biology 10.

Past Utilization of Insects

A broader view of insect utilization can be seen from the data covering insect utilization from 1969 to 1973 (Table XVI). Twenty-four types of investigations were reported, nine of which dealt directly with behavior. These are topics 14 to 22 in the accompanying table. Another eight investigations dealt with

TABLE XVI

USES OF INSECTS, 1969 - 1973
REFERENCES

a 18 respondents, two with one year experience, one with two years experience, and one with one year experience in Biology 20 and Biology 30.

b Reasons for using (numerals indicate the number of teachers reporting the topic):
1 General Study
2 Taxonomy (classification)
3 Physiology (structure and function)
4 Genetics (heredity)
5 Morphology (structure)
6 Ecology - general
7 - dispersal
8 - overpopulation
9 Applied Entomology - parasitology (Veterinary Entomology)
10 - bacteriology (Medical Entomology)
11 - crop relationships (Agricultural Entomology)
12 - insecticide chain reaction with chicks (Agricultural Entomology)
13 - control methods (Agricultural Entomology)
14 Behavior - general
15 - social
16 - feeding
17 - tunnelling
18 - trail laying
19 Responses to - chemicals
20 - light
21 - electricity
22 - pollutants
23 Use in cleaning skulls
24 Use in feeding other organisms

c Total number of different reasons for using the insect.

d Collection and study of cocoons.

e Total number of different teachers using insects for this reason.

f Total number of different species used for each reason (excluding general and aquatic collections).

TABLE XVI

USES OF INSECTS, 1969 - 1973[a]

ORGANISM	REASON FOR USING[b]																								c
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
ORTHOPTERA																									
Grasshopper		1	2								1	1		1					1						6
HEMIPTERA																									
Scale Insect					1		1						1												3
Water Strider						1																			1
Giant Water Bug	1																								1
LEPIDOPTERA																									
Tent Caterpillar											1					1									2
Moth		1	1																						2
Butterfly		2	2																						2
Hawk Moth					1																				1
DIPTERA																									
Drosophila				10	1			1														1			4
Blowfly														1											1
Housefly					2					1				1										1	4
Sheep Ked	1								1																2
Mosquito	1																								1
HYMENOPTERA																									
Ant					1									5	5	2	1	1							6
Bee			1																						1
COLEOPTERA																									
General			1																						1
Mealworm		1	1		1									1						1	1		1	1	8
Potato Beetle														1											1
Ladybird Beetle																1									1
Water Beetle		1	1																						2
GENERAL COLLECTION	1	5	3		1d																				4
AQUATIC COLLECTION	1	1	1			3																			4
TOTAL TEACHERS e	3	7	6	10	3	3	1	1	1	1	2	1	1	7	5	4	1	1	1	1	1	1	1	2	
TOTAL INSECTS f	3	5	7	1	6	1	1	1	1	1	2	1	1	6	1	3	1	1	1	1	1	1	1	2	

closely related fields, ecology (three aspects) and applied entomology (five aspects). Each teacher reported anywhere from one to nine types of investigations, the average being five types of investigations for each of the 15 teachers using insects.

The most common types of investigations were those involving genetics (reported by 10 teachers and all dealing with Drosophila), taxonomy (seven teachers), general behavior (seven teachers), physiology (six teachers), and social behavior (reported by five teachers and all dealing with ants). The greatest variety of insects used in any one topic was in the study of structure and function. Teachers used a total of seven different species to illustrate this principle. Six different species were utilized in the study of morphology, six species in the study of general behavior, and five species in the study of taxonomy.

On the average, each insect was used for one or two different topics by the teacher or the students. From the total survey, the mealworm was used for the greatest variety of topics (eight). Other insects used for a diversity of reasons were the grasshopper (six topics), ant (six topics), fruitfly (four topics), and housefly (four topics). General collections were maintained for general study by one teacher, for the study of taxonomy by five teachers, for the study of physiology by three teachers, and for the study of morphology by one teacher. Similarly, aquatic collections were maintained for general study by one teacher, for the study of taxonomy by one teacher, for the study of physiology by one teacher, and for general studies in ecology by three teachers.

<u>Past Utilization of Other Animals</u>

Fifty specific animals were listed in connection with ethology projects conducted during the period 1969 to 1973 (Table XVII). These were reported by 14 out of the 18 teachers surveyed (77.8%). From one to 24 different organisms were listed by each teacher, the most frequent number of organisms listed being three or five. The organisms mentioned most frequently were the white mouse (eight teachers), ant (five teachers), and planaria (four teachers).

Of the five major groups of organisms used, 36% (18 out of the 50 animals) were mammals, 26% (13) were birds, 26% (13) were invertebrates, eight percent (four) were fish, and four percent (two) were amphibia. Of the mammals, 11 (61.1%) were rodents, six of these being feral organisms. Of the invertebrates, nine (69.2%) were insects. Thirteen of the 50 animals were commercial organisms or domestic organisms (26%).

From the table it would appear that mammals and birds were the most frequently used organisms. However, 18 of all organisms listed were reported by the same teacher (marked by an asterisk on the table). This accounts for 36% of the species listed. Of the 93 different behavior projects, 27 of these (29%) were also reported solely by this one individual. As a result, the total number of organisms, particularly in classes Aves and Mammalia, and the total number of projects was not as extensive nor as diverse in the total teacher population as it may first appear.

Each teacher reported anywhere from one to eight types of investigations into behavior, the majority of the teachers reporting

TABLE XVII

ANIMALS USED IN PROJECTS DEALING WITH BEHAVIOR, 1969 - 1973
REFERENCES

a 18 respondents, two with one year experience, one with two years experience, and one with one year experience in Biology 20 and Biology 30.
b Total number of teachers reporting utilization of the organism.
c Aspect of Behavior (numerals indicate the number of teachers reporting the topic):
 1 General Behavior
 2 Ecology and Behavior
 3 Range and Distribution
 4 Species Interaction
 5 Reproductive Behavior
 6 Nesting Behavior (Birds)/Denning Behavior (Mammals)
 7 Feeding Behavior, Food Selection
 8 Learning (Conditioning)
 9 Maze Learning
 10 Isolated versus Group Behavior
 11 Phototaxis (Response to Light)
 12 Thermotaxis (Response to Heat)
 13 Responses to Salinity
 14 Crop Relationships
 15 Responses to Pesticides
 16 Responses to Pollutants
 17 Responses to Alcohol
 18 Cage Interactions (*Peromyscus* and *Mus*)
 19 Barnyard Behavior
 20 Social Behavior
 21 Responses to Chemicals
 22 Tunnelling
 23 Trail Laying
 24 Responses to Electricity
d Total number of different aspects investigated with each organism.
e Behavior involving regeneration.
f Species unknown.
g Various species.
h Feeding behavior upon hatching.
i Two teachers reported projects dealing with responses to smoke and one teacher reported a project dealing with responses to mercury.
j Interactions with deer.
k Total number of different species used to investigate each aspect of behavior. Unknown species have not been tabulated.
l Total number of different teachers reporting investigation of each aspect of behavior including projects involving unknown species.
* All projects marked with an asterisk were reported by the same individual.

TABLE XVII

ANIMALS USED IN PROJECTS DEALING WITH BEHAVIOR
1969 - 1973[a]

ORGANISM	TOTAL b	ASPECT OF BEHAVIOR[c] 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL d
INVERTEBRATES																										
INSECTS																										
Grasshopper	2	1																				1				2
Tent Caterpillar	1							1																		1
Drosophila	1																1									1
Blowfly	1	1																								1
Housefly	1	1																								1
Ant	5	5						2													5		1	1		5
Mealworm	1	1										1													1	3
Potato Beetle	1	1																								1
Ladybird	1							1																		1
OTHER																										
Planaria	4					4[e]						1														2
Clam	1	1																								1
Snail	1	1																								1
Crayfish	1	1																								1
FISH																										
Trout	1	1																								1
Tropical Fish (f)	1											1														1
Goldfish	3								1				1	1		1										4
Swordtails	1					1																				1
Guppies	2					1										1										2
AMPHIBIA																										
Frogs (f)	2	2				2																				2
Chorus Frog	1	*																								1
Boreal Toad	1	*																								1
BIRDS																										
General (f)	1						1																			1
Grebe	1	*	*																							2
Hawk (f)	1	1																								1
Red-tailed Hawk	1		*			*																				2
Swainson's Hawk	1					*																				1
Prairie Falcon	1	*				*																				2
Upland Game Birds (g)	1														*											1
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	

TABLE XVII (Continued)

ORGANISM	TOTAL b	ASPECT OF BEHAVIOR[c] 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL d
California Gull	1	*	*																							2
Tern	1		*																							1
Owl (f)	1	1																								1
Great Horned Owl	1		*																							1
Swallow	1						1																			1
Crow	2	1	*				*																			3
Magpie	1		*				*																			2
Robin	1						*																			1
Sparrow	1						*																			1
Domestic Chicken	1							1[h]																		1
MAMMALS																										
RODENT (FERAL)																										
Vole	1	1																								1
Microtis	1							*																		1
Peromyscus	2																	1	1							2
Richardson's Ground Squirrel	2	*		1				1																		3
Porcupine	1	1																								1
Beaver	1		*																							1
RODENT (COMMER.)																										
Hampster	1					1		1		1																3
Guinea Pig	2							1		1																2
White Mouse	8	2				2		3	1	1	1	1					3[i]	2	1							10
White Rat	1									1																1
Gerbil	2	1				1				1																3
OTHER																										
White-tail Deer	1		*																							1
Mule Deer	1		*																							1
Coyote	1				*[j]																					1
Red Fox	1						*																			1
Lamb	1	1																								1
Semi-wild Domestic Cat	1																			1						1
Domestic Dog	1	1																								1
TOTAL ORGANISMS (k)		23	10	1	1	9	6	9	2	5	1	3	1	1	1	2	2	2	2	1	1	1	1	1	1	
TOTAL TEACHERS (l)		12	1	1	1	7	3	7	3	4	1	4	1	1	1	1	4	3	1	1	5	1	1	1	1	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	

four different projects. The most common types of investigations involved general behavior (12 teachers reporting such projects), reproductive behavior (seven teachers), feeding behavior (seven teachers), social behavior (five teachers), maze learning (four teachers), phototaxis (four teachers), and responses to pollutants (four teachers). Twenty-three different organisms were named for the study of general behavior. The only other aspects of behavior in which a diversity of organisms were used were behavior related to the ecology of the organism (11 species, all reported by one teacher), nesting or denning behavior (six species), feeding behavior and food selection (nine species), reproductive behavior (nine species), and maze learning (five species).

The majority of the organisms utilized were used for only one or two reasons by the teacher or the students. From the total survey, only the white mouse was used for a diversity of reasons (10 different topics). The ant was the next species having the greatest diversity (five different topics), followed by the goldfish (four different topics). Of the nine insects used in the study of behavior, the ant was used for the greatest variety of reasons. The mealworm was used to investigate three topics and the grasshopper was used to investigate two topics, the remaining species being used for only one specific topic each.

Past Utilization of Plants

In addition to the animals mentioned, 11 species of plants were listed in connection with responses to stimuli (Table XVIII). Eight of the 18 teachers mentioned plants (44.4%). Each teacher

TABLE XVIII

PROJECTS INVOLVING PLANT RESPONSES, 1969 - 1973[a]

ORGANISM	NO. OF TEACHERS USING	NO. OF TEACHERS REPORTING BEHAVIORAL ASPECT (b) 1	2	3	4	5	6	7	NUMBER OF ASPECTS[c]
Sunflower	1	1	1						2
Corn	2	2	1	1					3
Radish	1	1	1	1					3
Rye	1	1	1						2
Barley	1	1	1						2
Tomato	1	1		1	1				3
Wheat	1	1		1	1				3
Oats	1	1		1	1				3
Common Bean	6	6	3	1	2	1			5
Geranium	4	4	1	1	1	1			5
Coleus	1	1	1						2
Unidentified	2						1	1	2
TOTAL SPECIES[d]		11	8	7	5	2	1	1	
TOTAL TEACHERS[e]		7	4	2	2	1	1	1	

a 18 respondents, two with one year experience, one with two years experience, and one with one year experience in Biology 20 and Biology 30.

b Behavioral aspect:
1 Response to Light (Phototropism)
2 Response to Gravity (Geotropism)
3 Response to Magnetic Rays (Magnetotropism)
4 Response to Chemicals (Chemotropism)
5 Response to Noise
6 Response to Music
7 Emotions

c Total number of different aspects investigated with each organism.

d Total number of different species used to investigate each behavioral aspect.

e Total number of different teachers reporting investigation of each behavioral aspect.

listed from one to five species, the majority naming three species. The species used most often by teachers were the common bean (six teachers), geranium (four teachers), and corn (two teachers), all other species being used by only one teacher each. Teachers used plants for one to four types of responses, the majority of the teachers reporting two types of projects dealing with behavior.

The most common types of projects were those dealing with phototropism (reported by seven teachers) and geotropism (reported by four teachers). The greatest variety of plants used in any one topic was in the study of phototropism. Eleven different species were used to investigate this topic, compared with eight species used to investigate geotropism, seven species to investigate magnetotropism, and five species to investigate chemotropism. From the total sample, the common bean and the geranium were used for the greatest variety of reasons (five types of projects for each).

V. SUMMARY OF TEACHER INTERVIEW DATA

The number of entomology courses taken by a teacher, the recency of university training, and the textbooks used in secondary school biology classes did not appear to influence the content or method of conducting student projects. A greater proportion of rural teachers than urban teachers used the project method. Only one teacher did not use this method in any biology class taught and only two teachers did not use this method in every biology class. A greater number of projects dealing with behavior, insects, and insect behavior were reported by rural teachers, teachers with a greater number of biology methods courses in their university

background, and teachers reporting that accessibility of natural resources was excellent. There was a higher incidence of projects dealing with behavior among teachers having less teaching experience, less university training, more university biology courses, smaller classes, and a greater number of secondary school biology classes. The incongruity between the number of years of university training and the number of university biology courses taken would appear to indicate that further research is required for these two variables. A higher incidence of projects dealing with live organisms was found among teachers having less teaching experience. A higher incidence of projects dealing with insects was found among teachers who had graduated since 1969 and teachers who had smaller secondary school biology classes.

More extreme amounts of class time were devoted towards student projects by teachers having less teaching experience and less university training. The most frequent forms projects took were individual and group projects. Individual projects tended to be more common in Biology 30 than in Biology 10 or Biology 20. Most teachers allowed students to choose their own topics and no teacher relied solely on teacher choice. Reliance on student choice appeared to be more frequent among rural teachers and teachers having large classes. Concurrent implementation appeared to be the most common method of project implementation. Most teachers devoted the same amount of class time towards projects in each grade, the most frequent amounts of class time being one, three, and four weeks.

The most important objectives of projects according to the teachers in this survey were the items "to develop and encourage

attitudes of inquiry" and "to give each student an opportunity to do an in-depth study in an area of his interest". The least important objectives were the items "to allow students to evaluate the work of peers" and "to evaluate the effect of scientific discoveries". The objectives that teachers felt would most likely be achieved by projects dealing with insect behavior were the items "to develop and encourage attitudes of curiosity and inquiry" and "to enable students to practise methods of proper scientific reporting". The major advantages of projects dealing with insect behavior as seen by these teachers were the items "development of skill in scientific thinking and problem solving" and "provision for active student involvement". The least important objective was the item "stimulation of further research". The main problems indicated by the teachers in this survey were the following items: lack of proper equipment, lack of adequate reference material, exercises are too time consuming, and insufficient teacher background in collecting and culturing techniques.

It was found that 94.4% of the teachers surveyed were currently using live organisms and 83.3% were using feral species. However, the proportion of projects involving live organisms varied considerably between teachers for each grade. Only 33.3% of the teachers were currently using insects although 83.4% of the teachers reported that they had used insects over the period 1969 to 1973. The insects reported most frequently were Drosophila, houseflies, grasshoppers, ants, and mealworms. The majority of these insects were used in projects and the majority were collected by students. All teachers reporting the use of insects also reported that attempts

were made at culturing them. The majority of the insects were used for periods of one to four weeks.

Although 72.2% of the teachers reported the study of behavior in their classrooms, 50% of the teachers indicated that projects involving behavior accounted for less than 20% of all projects being conducted. Only three teachers reported projects on insect behavior currently being conducted at the time of the interview. The most common types of studies involving insects in this survey were genetics, taxonomy, general behavior, physiology, and social behavior. On the average, each insect was used for one or two different topics.

Fifty species of animals were listed in connection with projects involving behavior. Mammals, birds, and invertebrates were the groups mentioned most frequently. The most common mammals mentioned were rodents and the most common invertebrates were insects. The most common types of investigations were those involving general behavior, reproductive behavior, and feeding behavior. The majority of the organisms were utilized for only one or two topics.

Eleven species of plants were listed in connection with responses to stimuli. The species mentioned most frequently were the common bean and the geranium. The most common types of projects mentioned were those involving phototropism and geotropism.

CHAPTER V

DISCUSSION OF TEACHER INTERVIEW DATA

I. TEACHER PROFILE

If a teacher has enrolled in an optional university course such as a course in entomology, it may be suspected that his interest in the subject, combined with his university training in that area, would influence his content emphasis when teaching biology. Similarly, if a biology teacher has attended university recently it is likely that he has been exposed to new trends and concepts in education and in science. This exposure might also influence his teaching techniques and the content of the subjects he teaches. The use of live organisms, the project method, and the field of ethology are three aspects of biology or biology teaching receiving recent attention. In this study, teachers who had taken a course in entomology and teachers who had attended university recently did not appear to differ from those who had not attended university recently and who did not have an entomology background with respect to the content or implementation of projects in secondary school biology.

It might also be suspected that a teacher's choice of texts in the subjects he teaches may reflect his own emphasis in teaching. In Biology 10 and Biology 20, the teacher has a choice between three textbooks, the BSCS Green Version (1968), the BSCS Yellow Version (1968), and Otto and Towle (1965). Lee et. al. (1967) noted that the Green Version approached the study of biology from the ecological

and behavioral perspectives whereas the Yellow Version approached biology from the concepts of biological unity, diversity, and continuity. In the preface of Modern Biology, Otto and Towle (1965) indicated that their text approached the study of biology through basic biological principles in molecular and cellular biology, genetics, reproduction, evolution, and classification. Despite these differences in approaches, no difference in teaching methodology within the project context could be found between teachers using different texts. Rather, teachers tended to use the textbook recommended by the Alberta biology curriculum guide (1971).

This study found that teachers who had taken a biology methods course tended to have a greater percentage of classroom projects dealing with behavior, insects, and insect behavior than those teachers who had not taken a biology methods course. Dyke (1970) similarly found a greater percentage of teachers with a methods course used mammals in the classroom. This study also found a greater percentage of projects involving behavior among teachers with a greater number of university biology courses. Dyke (1970) found a low positive correlation between the number of university biology courses and the use of live mammals. However, Anderson (1972) found no significant difference between the number of biology courses taken and the types of projects conducted. The lack of sufficient categories at the upper end of his scale for this variable may account in part for this inconsistency.

Teachers having one to three years of teaching experience reported a greater percentage of classroom projects dealing with live organisms. They also devoted more extreme amounts of class

time towards projects, a greater percentage of these teachers devoting zero or six weeks of class time compared with three to four weeks for teachers having over eight years experience. These findings are in agreement with those by Dyke (1970), who found teachers using live mammals had three years or less experience. On the other hand, Anderson (1972) found no significant difference between years of teaching experience and the types of projects conducted. This inconsistency indicates the need for further research with respect to this variable.

Teachers having at least three and one half years of training but less than five years of training were found to have more student projects dealing with behavior than teachers having five or more years training. Teachers with less than five years training also had a greater percentage of teachers devoting both extremes of class time to these enterprises. Again, Anderson's (1972) finding that there was no significant difference between types of projects and years of university training, and the incongruity between this variable and the number of university biology courses taken within this inquiry, indicates a need for further research before any firm conclusions can be drawn.

Teachers who graduated since 1969 were found to have more students conducting projects dealing with insects than teachers who graduated before 1969. There is no clear reason for this relationship and the finding might be attributed to the small sample size in this inquiry. Of those teachers devoting zero or six weeks of class time towards projects, a greater percentage had graduated since 1969. This finding supports the earlier finding in this inquiry, that less

experienced teachers devoted more extreme amounts of class time towards projects.

Those teachers teaching a fewer number of classes tended to have fewer student projects on behavior whereas those with smaller class sizes had more projects on both behavior and on insects. Those teachers with smaller classes also tended to rely upon both teacher choice and pupil choice in deciding on project topics. Teachers who rated accessibility of natural resources as being excellent tended to have more student projects on behavior, insects, and insect behavior. This may possibly reflect a greater utilization of natural resources in general. To the knowledge of the writer, no studies have been conducted in which the variables of year of graduation, the number of classes taught, class size, or teacher opinion of accessibility of natural resources have been related to the use of projects. A survey of a larger population will be required before firm conclusions can be drawn about these variables.

Rural teachers were found to have a greater percentage of student projects dealing with behavior, insects, and insect behavior. Rural and urban teachers were also found to differ in the proportion of teachers relying on student choice of project topics, and in the proportion of teachers conducting projects concurrently. In comparison with the findings by Anderson (1972), only two points of agreement appear to exist: a greater percentage of rural teachers rely on pupil choice of topics and a greater percentage of rural teachers conduct projects concurrently with the course (Table XIX).

The small population size of both of these studies probably

TABLE XIX

COMPARISON OF FINDINGS ON RURAL/URBAN DIFFERENCES

PROJECT ASPECT			PERCENTAGE OF TEACHERS FRANZ	ANDERSON
USED BIOLOGY PROJECTS	Rural	Biology 10	100	71
		Biology 20	91.7	71
		Biology 30	100	80
	Urban	Biology 10	67	72.8
		Biology 20	60	80
		Biology 30	80	100
METHOD OF CHOICE	Rural	Pupil	75	57.1
		Pupil and Teacher	25	42.9
	Urban	Pupil	60	45.5
		Pupil and Teacher	40	54.5
METHOD OF IMPLEMENTATION	Rural	Concurrent	91.7	100
		Unit	8.3	0
		Both	0	0
	Urban	Concurrent	80	36.3
		Unit	0	63.7
		Both	20	0

accounts for the different findings, and when considered together, these two studies appear to indicate that there are no significant differences between rural and urban teachers with respect to project implementation. With consolidation of schools in the rural areas the size of school populations, the size of classes, and the availability of classroom space are probably similar in both rural and urban schools today. Consequently, the problems encountered by the urban teacher in project implementation are probably somewhat similar to the problems encountered by the rural teacher.

II. PROJECT IMPLEMENTATION

The most common form projects took in this inquiry was a combination of individual and group projects, 64.3% of the teachers reporting the use of this form in all three grades taught. This is lower than Anderson's (1972) finding of 83.3%, but his figure may be questionable since there is one teacher unaccounted for in his statistics. The number of teachers using all three forms of projects were in the minority in both of these studies.

Fewer teachers were found to be omitting projects in this inquiry than was reported by Anderson. In this inquiry two of the 18 Biology 10 teachers, three of the 17 Biology 20 teachers, and one of the 17 Biology 30 teachers did not conduct projects. Anderson's findings were five out of 18, eight out of 18, and one out of 16 teachers respectively. This difference may possibly reflect a greater acceptance of this method of instruction, or it may be due to the small population sizes in both of these studies.

All of the reasons for not conducting projects given by teachers in this inquiry were also given by teachers in Anderson's study. It is the opinion of the writer that most of these problems can be overcome by the selection of proper projects. Class projects can be conducted in place of individual or group projects if classes are too large or if the teacher has a heavy teaching load. This approach might reduce the demand on teacher time and school facilities. Projects utilizing simple equipment or based on field observations can be conducted if there is a lack of facilities. Short-term projects can be conducted if courses are taught on a half-semester basis. The writer is in agreement with Anderson's view that it is regrettable that some teachers have eliminated projects rather than adapting the method to overcome these problems.

No teachers in this inquiry relied on their own choice of topics exclusively and 64.3% allowed their students to choose the topics. Similarly, Anderson (1972) found none of the teachers relied only on teacher choice of topics and 50% relied on student choice. These methods are in agreement with the recommendations of most theorists on the project approach. The project is one method by which students can pursue topics of their own interest, but they require assistance from the teacher in selecting and investigating these topics.

Only one teacher (5.9%) used the unit method of project implementation exclusively and only one teacher used the unit method in addition to projects conducted concurrently with the course. Darroch (1972) found 23% of the Biology 30 teachers surveyed used the unit method and Anderson (1972) found 38.9% of

all teachers surveyed used the unit method. As noted by Anderson (1972), the unit method tends to prevent the student from becoming bored with the project, but it also places limitations on the types of projects which can be conducted. Only one teacher in this inquiry conducted class projects to introduce the approach before allowing students to work on separate topics as is suggested in the Edmonton Public School Board guide (1970).

The majority of the teachers surveyed devoted the same amount of class time towards projects in each of the three courses taught. Those who altered the amount of class time devoted more time in Biology 30 than in Biology 10 or Biology 20. It was also found that 11.8% of the teachers devoted no time and 29% devoted only one week of class time towards projects. Most educators recommend that projects be conducted in class time [Richardson (1959), Richardson and Cahoon (1951), Thurber and Collette (1965), and Washton (1967)].

By conducting projects in class time, even if only partially, the teacher has greater ability to supervise, direct, and encourage students. The teacher also has greater opportunity to discover and assess individual needs and interests and individual weaknesses and strengths. The writer is in agreement with Anderson's (1972) observation that students need class time for assistance from the teacher and that course content need not be reduced to achieve this. Projects can be adjusted to the length of the class period and projects can be adapted if the teacher wishes to ensure that students are exposed to specific concepts.

III. TEACHER OPINIONS ON PROJECTS

Objectives

The most important objectives of projects according to the teachers in this inquiry were the following items: to develop and encourage attitudes of inquiry, to give each student an opportunity to do an in-depth study in an area of his interest, and to encourage a respect and feeling for living things. Of least importance were the following items: to permit the development of empathy with the scientific researcher, to evaluate the effect of scientific discoveries, and to allow students to evaluate the work of peers. These last two objectives were those recommended by the Edmonton Public School Board project guide (1970) for projects at the junior high school level. From this inquiry it would appear that biology teachers do not feel that these are major objectives for secondary school biology students.

The objectives ranked first and third in importance by the teachers in this inquiry were also ranked first and third for achievement of the objective by projects involving insect behavior. Similarly, the two objectives ranked lowest in importance were also ranked lowest in achievement. The objective "to give each student an opportunity to do an in-depth study in an area of his interest", while being ranked second in importance, was ranked seventh for achievement by projects dealing with insect behavior in this inquiry. Only 46.7% of the teachers indicated high or very high achievement whereas the teachers in Anderson's (1972) study felt that this objective was most likely to be achieved by the project method,

61.1% indicating high or very high achievement.

On all other items listed by Anderson a lower percentage of teachers indicated achievement of the objective by projects in general than did teachers in this inquiry for achievement of the objective by projects involving insect behavior (Table XX). Furthermore, in the study by Dyke (1970) 66.7% of the teachers felt that the use of live mammals would create interest and in the study by Jacknicke (1968) 64% of the teachers felt the use of local resources would stimulate student interest and motivation. It would appear that teachers in this inquiry felt relatively fewer students would be interested in insect behavior. However, this finding is contradicted by the teacher's views on the advantages of insect behavior projects as noted in the next section.

Two other objectives were ranked high for achievement by projects involving insect behavior. These two items were "to enable students to practise methods of proper scientific reporting" and "to further familiarize students with research methods". Both objectives were also ranked high in importance by the teachers in this inquiry. From this it would appear that these teachers felt the highest value of projects involving insect behavior was to illustrate and develop the process aspects of biology.

Advantages

This opinion is further supported by the teacher's views on the advantages of projects involving insect behavior, the greatest advantage indicated being the item "develops skill in scientific thinking and problem-solving". This advantage was emphasized by

TABLE XX

COMPARISON OF FINDINGS ON ACHIEVEMENT OF PROJECT OBJECTIVES

OBJECTIVE	PERCENTAGE OF TEACHERS INDICATING HIGH OR VERY HIGH ACHIEVEMENT BY USING:	
	BIOLOGY PROJECTS Anderson	INSECT BEHAVIOR PROJECTS Franz
a. To give each student an opportunity to do an in-depth study in an area of his interest	61.1	46.7
b. To encourage students to formulate questions for investigative purposes	38.9	60
c. To further familiarize students with research methods	44.4	66.7
d. To enable students to practise methods of proper scientific reporting	44.4	73.3
e. To permit the development of empathy with the scientific researcher	44.4	46.7
f. To develop and encourage attitudes of curiosity and inquiry	50	73.3
g. To encourage a respect and feeling for living things	50	66.7
h. To provide material supplemental to the course	Not Listed	46.7
i. To evaluate the effect of scientific discoveries	Not Listed	26.7
j. To allow students to evaluate work of peers	Not Listed	40

such theorists as Kastrinos (1956), Stevenson (1928), and Richardson (1959) and was cited as an advantage of the project method over the lecture method in the experimental research by Novak (1958). On the other hand, Gagné (1963) and Piaget (1952) have indicated basic requirements which some secondary school students might lack for the development of such skills.

Surprisingly, only 38.9% of the teachers in Anderson's (1972) study felt projects provided an opportunity for the student to work like a scientist. Anderson noted that this may be due to a lower number of investigative research projects in his rural population and that there was some contradiction in the opinions of the rural teachers since they indicated achievement of the related objective "to enable students to practise methods of proper scientific reporting".

Also rated high in this inquiry were the item "provides for active involvement" emphasized by the theorists Richardson (1959) and Duffy and Putt (1969), and the item "can be used to illustrate biological principles" emphasized by Chancey (1968), Washton (1967), Mills (1966), and Scott (1962). The concept of individualized instruction has received recent emphasis in education, especially along the lines of personal investigations in science as noted by Howes (1970) and Brandwein (1962). In this inquiry 72.2% of the teachers ranked this as being a high or very high advantage of using projects involving insect behavior and in Anderson's (1972) study 66.7% of the teachers ranked the concept as being one of the most important advantages of the project method. Both Foster (1970) and Novak (1958) reported achievement of individualized instruction

with the project approach in their experimental research.

It was found that 66.7% of the teachers in this inquiry felt that the item "provides students with content of special interest" was a high or very high advantage of projects on insect behavior. This contradicts the earlier consensus by these teachers in which only 46.7% of the teachers felt that projects on insect behavior gave each student an opportunity to do an in-depth study in an area of his interest (page 99). In comparison, Anderson (1972) found 72.3% of the teachers felt that the item "the student can learn content of special interest to him" was of considerable or very great advantage for projects in general. In this respect the findings in this inquiry are also in agreement with the findings by Dyke (1970) for mammals and of Jacknicke (1968) for local resources as described on page 99.

A major objective of the project method according to Kilpatrick (1935) was to lead the student on to further knowledge, and Brown (1967) stated that the project method stimulated research amongst his students. However, only 44.4% of the teachers in this inquiry rated this item as being an important advantage of projects on insect behavior. Similarly only 33.3% of the teachers in Anderson's (1972) study rated this as an important advantage of projects in general. From these findings it would appear that the stimulation of further research was not considered a major objective of the project method by the teachers surveyed.

The only other advantage rated low by teachers in this inquiry was the item "develops techniques in using laboratory equipment". Only 50% of the teachers in this survey and only 50%

of the teachers in Anderson's (1972) study rated this item as being an important advantage.

Disadvantages

The major disadvantages of using projects involving insect behavior indicated by the teachers in this inquiry were consistent with the problems usually suggested in the literature for any type of project. Teachers felt that the most important problem was the lack of proper equipment, 61.1% of the teachers ranking this problem as great or very great. Anderson (1972) found that 44.4% of the teachers felt this was a problem in projects in general, but one teacher is unaccounted for in his statistics.

Forty-seven percent of the teachers in Dyke's (1970) study felt that the lack of facilities was a reason why teachers did not use live mammals, and 45% of the teachers in Jacknicke's (1968) study felt that lack of facilities for collecting and culturing was a reason why teachers did not use local resources. In the opinion of the writer, the lack of facilities may prevent the implementation of certain projects involving insect behavior, especially in the areas of rhythmic behavior and responses to polarized light, but even in these categories of behavior projects involving simple equipment can be conducted. Sample projects have been suggested by the writer in Chapter VII.

Fifty percent of the teachers in this inquiry and 61.1% of the teachers in Anderson's (1972) study felt that the lack of adequate reference material was an important problem. Fifty percent of the teachers in this inquiry also felt that projects

involving insect behavior were too time consuming. Dyke (1970) found that 77% of the teachers felt extra teacher involvement was a reason why teachers did not use live feral mammals and Jacknicke (1968) found that 63% of the teachers felt the use of local resources was too time consuming.

Fifty percent of the teachers in this inquiry also felt that insufficient teacher background in collecting and culturing techniques was a great or very great problem. Similarly, Anderson (1972) found 33.3% of the teachers felt insufficient biology background was a problem in conducting projects and Dyke (1970) found 30% of the teachers felt lack of teacher knowledge was a problem. Jacknicke (1968) found 63% of the teachers felt that inadequate knowledge of culturing techniques and 54% of the teachers felt that inadequate knowledge of how to obtain living specimens were important reasons for not using local resources.

On the other hand, teachers in this inquiry felt that lack of adequate space was a minor problem, only 27.8% of the teachers rating this disadvantage as being a great or very great problem in contrast to 50% of the teachers in Anderson's (1972) study. Difficulty in culturing insects and difficulty in handling insects were also felt to be minor problems by the teachers in this inquiry. These views were also expressed by teachers in studies by Jacknicke (1968) and Kelly and Wray (1971) respectively. The housing and feeding of insects were also felt to be minor problems in the Kelly and Wray study but the maintenance over holidays and difficulties in breeding were felt to be significant disadvantages.

From the results of this inquiry in comparison with the

findings of other studies, the writer is in agreement with the conclusion by Kelly and Wray (1971) that one of the major needs is the development of guides to provide teachers information on the value and maintenance facility of specific species. The writer would also concur with the conclusions by Jacknicke (1968) and Dyke (1970) that there is a need to provide teachers with information on the use of live organisms. Furthermore, there appears to be a need for the development of project guides for specific organisms and specific topics to provide assistance to both teachers and pupils in the selection of projects. Of prime consideration would be projects requiring little need for reference material and equipment, exercises that can be conducted within the time available to the teacher, and organisms that are easy to obtain and maintain.

IV. PROJECT CONTENT

Live Organisms

It was found in this inquiry that the only teacher not using live organisms was a teacher having no background in biology or biology methods and teaching one grade temporarily due to excessive biology enrolments. This kind of situation is unfortunate but is one which nonetheless exists in the schools. Not only was it found that 94.4% of the teachers surveyed used live organisms, but 84.4% used feral organisms exclusively or in addition to commercial organisms. Furthermore, 78.6% of the teachers conducting projects in all three biology courses reported that over half of their projects involved live organisms. These findings are in sharp contrast to Abbott's (1954) observation that only eight percent of the instructional

methodologies reported involved live organisms, Jacknicke's (1968) observation that 64% of the teachers surveyed used local organisms, and Dyke's (1970) observation that 20% of the teachers surveyed used live mammals.

There are three possible explanations for the difference between the results of this inquiry and the results of earlier studies. First, unlike the other studies, this inquiry surveyed only secondary school biology teachers in a small number of Alberta schools. Abbott's study was conducted in the United States and both Dyke and Jacknicke included grade eight teachers in their surveys. Second, emphasis has been placed on the use of live organisms and local resources over the past five years. It may be that teachers are becoming more comfortable with this method of instruction or more cognizant of its value. Third, and perhaps of greatest significance, is the fact that projects have become part of the Alberta secondary school biology curriculum. Not only does the project method lend itself to the use of live organisms, but the choice of topics and the decision to use live organisms is at least in part a prerogative of the student. Prior to 1969 this decision was probably one made primarily by the teacher. Furthermore, the teachers in this inquiry may have been better trained in the use of live organisms and the project method than teachers in earlier studies.

It should also be noted that despite the greater percentage of teachers reporting the use of live organisms in this inquiry, the diversity of organisms utilized by each teacher and the length of time the organism was used was still low. This is particularly

evident from the summary of results for specific groups of organisms in the preceding chapter. Furthermore, the percentage of projects dealing with live organisms varied with each grade, being highest in Biology 20 and lowest in Biology 30. This may possibly be due to the subject content of each grade. Since Biology 10 is an introductory course teachers may feel that students lack the background for working with live organisms. Since Biology 30 deals largely with human physiology, a greater number of projects in this grade might deal with this topic and use man as the experimental animal.

Insects

Although 83.4% of the teachers surveyed reported having used insects during the period 1969 to 1973, the 33.3% currently using insects at the time of the survey was probably representative of the yearly average. This is closer to Jacknicke's (1968) observation that 45.5% of the teachers in his survey were using local insects. Similarly, the finding of this inquiry that two insects in addition to *Drosophila* were usually listed by each teacher for the period 1969 to 1973 is consistent with Jacknicke's finding that usually one insect was used per teacher. Furthermore, although a total of 19 species was listed, each species was usually used by only one teacher.

Out of the 18 teachers surveyed, 61.1% reported the use of *Drosophila*, 27.8% the use of houseflies, 27.8% the use of grasshoppers, 27.8% the use of ants, 22.2% the use of mealworms, and 18.2% the use of butterflies. In comparison, Kelly and Wray (1971)

found 72% of the schools used locusts, 64% stick insects, 42% cockroaches, 34% bees, 16% mealworms, 13% Drosophila, seven percent flour-moths, and five percent Tribolium. Jacknicke (1968) found the most common insects used were the ant, bee, wasp, housefly, butterfly, and moth.

The exceptional use of Drosophila in this study is possibly related to the fact that it was used in two of the laboratory exercises of the former Biology 30 course for studies in genetics and was thus an insect familiar to most teachers and one probably recommended to students for projects involving heredity. Although neither Jacknicke nor Kelly and Wray reported the use of aquatic insects, three aquatic species were reported in this inquiry and 27.8% of the teachers reported the use of general collections of living aquatic insects.

The majority of the insects reported were used in projects, supporting the hypothesis that the implementation of projects in the curriculum has had some influence on the utilization of living organisms. Although Kelly and Wray (1971) found that schools depended mainly on the purchasing of live organisms, including insects, this study found that only three species of insects were purchased and that 67.5% of all cases of insect utilization were situations in which the students collected the insects. This is lower than Dyke's (1970) finding that all live mammals were brought in by the students and Jacknicke's (1968) finding that all local organisms were collected by the pupils with only 18% of the collections involving the teacher, but it is consistent with the observation by both writers that the major source of live material

has been pupil collection.

All teachers using insects also reported attempts at culturing insects, although only 60% of these teachers reported attempts at culturing feral species. This is in agreement with the finding by Kelly and Wray (1971) that the two groups most frequently bred were insects and mammals. On the other hand, Jacknicke's (1968) observation that there was only one attempt at culturing insects is considerably low, even if the survey covered only current utilization. Those insects cultured most frequently were those used most frequently by the total teacher population: the ant, Drosophila, housefly, and mealworm. Usually only one culture was maintained for each species used.

Kelly and Wray (1971) found that live organisms were usually used immediately or maintained for one term, few organisms being maintained for durations between these two extremes. Similarly, Dyke (1970) reported that live mammals were usually used for half a day or for six months. It was found in this inquiry, however, that insects were usually used for much shorter durations, 45.6% of the cases being maintained for one to four weeks. This again emphasizes the observation that although a high percentage of teachers have reported the use of live insects, in most cases this utilization has been only for a short period of time.

Behavior

Current Investigation

It was found in this inquiry that 72.2% of the teachers reported the study of behavior in their classrooms and that 76.5%

of the teachers using projects reported the inclusion of projects on behavior. However, 50% of the teachers using the project method in all three courses reported that projects on behavior accounted for only one to 20% of all the projects conducted. Furthermore, upon examining the organisms used and the topics investigated, it was found that a narrow range of organisms was being used in these projects and that a small number of aspects of behavior were being investigated.

Past Utilization of Insects

Of the 24 types of studies involving insects, nine of these were directly based on behavior. The most common types of studies were genetics (reported by 66.7% of the teachers), taxonomy (46.7%), general behavior (46.7%), physiology (40%), and social behavior (33.3%). In comparison, Jacknicke (1968) found that the most common uses of local organisms were for classification (71%), for using the microscope (57%), and for manipulation of materials (28%). Dyke (1970) found that the most common uses of small mammals were to study structure (50%), conditioning (33.3%), general behavior (33.3%), and feeding habits (33.3%).

In this inquiry five types of studies were usually reported by each teacher and usually only one or two topics were investigated for each insect by each individual despite the great diversity possible for each species as seen from the survey of all cases of utilization during the period 1969 to 1973. This is in agreement with Jacknicke's (1968) observation that 43% of the teachers used local organisms to investigate only one aspect of biology.

Similarly, each teacher used only one or two species over the period of five years covered in this inquiry despite the great diversity of species that can be used for each topic. This is also in agreement with Dyke's (1970) findings in which two or three mammals were used by each teacher. These observations again emphasize the need to provide teachers with information on the value and maintenance facility of live organisms as recommended by Kelly and Wray (1971). If a species is being maintained in the classroom, it would surely be more efficient to use this species to investigate a variety of aspects of biology. Furthermore, in the case of traditional topics chosen by pupils, it would surely be more illustrative and informative for the teacher and pupil alike to use previous projects as references to investigate different species each year rather than using the same species year after year. Maze learning in the white rat and social behavior in the ant are two such examples.

<u>Past Utilization of Other Animals</u>

The utilization of other animals in the study of behavior followed the same pattern as was found for the utilization of insects. Although a total of 50 species was reported for the period 1969 to 1973, usually only three or five species were reported by each teacher and 78% of the species were reported by only one teacher each. Kelly and Wray (1971) also noted that although over 100 species were utilized, the majority were used by very few schools. Since each species was used by only a few teachers in this inquiry, the proportion of the total number of projects for each

classification does not necessarily represent the number of teachers utilizing that group as shown in Table XXI. For example, although invertebrates accounted for only 22.6% of the 93 projects reported, 55.5% of the 18 teachers reported utilization of this group.

It was found in this inquiry that 66.7% of the teachers used live mammals and 22.2% used feral species. The most common mammals were white mice, gerbils, and guinea pigs. Dyke (1970) found 20% of the teachers were currently using mammals at the time of her survey and seven percent were using feral species, the most common mammals being white mice and tame rabbits. There are several possible reasons for the higher incidence of mammal utilization in this inquiry. This survey covered a period of five years and dealt with one specific use of mammals whereas the study by Dyke covered one year and all uses. Furthermore, these two studies involved different grade levels. Both studies do indicate an emphasis on commercial mammals by teachers.

Similarly, it was found in this inquiry that 55% of the teachers used invertebrates, 44.4% used insects, and 22.2% used platyhelminths. The clam, snail, and crayfish were the only other invertebrates listed and all three were used by one individual. These findings are consistent with Jacknicke's (1968) findings that 63% of the teachers used invertebrates, 45.5% used insects, and no teachers used coelenterates, nemathelminths, or rotifers. However, Jacknicke found 18% of the teachers used annelids, 27% used mollusks, 63% used protozoa, nine percent used platyhelminths, nine percent used arachnids, nine percent used chilopods, nine percent used diplopods, and 27% used crustaceans. The absence or lower

TABLE XXI

RELATIVE PROPORTIONS OF ANIMAL GROUPS USED TO STUDY BEHAVIOR

GROUP	SPECIES NO.	SPECIES PERCENT	PROJECTS NO.	PROJECTS PERCENT	TEACHERS NO.	TEACHERS PERCENT
INVERTEBRATES	13	26	21	22.6	10	55.5
INSECTS	9	18	16	17.2	8	44.4
Feral	7	14	12	12.9	8	44.4
Commercial	2	4	4	4.3	1	5.6
OTHER	4	8	5	5.4	5	27.8
Feral	2	4	3	3.2	5	27.8
Commercial	2	4	2	2.2	1	5.6
FISH	4	8	9	9.7	6	33.3
Feral	1	2	1	1.1	1	5.6
Commercial	3	6	8	8.6	4	22.2
AMPHIBIA	2	4	4	4.3	3	16.7
Feral	2	4	2	2.2	1	5.6
Commercial	Species Unknown		2	2.2	2	11.1
BIRDS	13	26	24	25.8	5	27.8
Feral	12	24	23	24.7	4	22.2
Commercial	1	2	1	1.1	1	5.6
MAMMALS	18	36	35	37.6	12	66.7
RODENTS	11	22	28	30.1	12	66.7
Feral	6	12	9	9.7	4	22.2
Commercial	5	10	19	20.4	10	55.6
OTHER	7	14	7	7.5	4	22.2
Feral	4	8	4	4.3	1	5.6
Commercial	3	6	3	3.2	3	16.7
TOTAL	50		93		18	

percentages of these groups in this inquiry may be due to the small size of the population or because the survey dealt only with animals used to study behavior. Furthermore, Jacknicke's study also included teachers of grade eight.

Seventy percent (35) of the organisms utilized in the study of behavior were feral species, but as was found for insect utilization, most species were used to investigate only one or two aspects of biology and an average of only four aspects of behavior were investigated under each teacher. Thus, despite the diversity of aspects that can be investigated and the diversity of uses that can be made of each organism, teachers appear to have concentrated on only a few aspects and a few species. This again indicates the need to provide teachers with information on the use of live organisms for more efficient utilization of local species.

Past Utilization of Plants

The utilization of plants appeared to follow the same trends as was found in the utilization of insects and other animals. Only two species of plants were commonly used by teachers and 72.7% of the species named were reported by only one teacher each. Each teacher used an average of only three species of plants and only two aspects of plant responses were investigated. Furthermore, all of the plants used were commercial species.

It would again appear that teachers have concentrated on only a few species and a few aspects of plant biology, but it is difficult to make definite conclusions in this respect since this inquiry investigated only one aspect of plant utilization. To the

knowledge of the writer, there have been no studies on plant utilization in Alberta as of this date. A study on the use of plants in secondary school biology which may provide additional insight into the findings of this inquiry is currently being conducted by Mr. Gary Schofield at the University of Alberta.

V. SUMMARY OF DISCUSSION

No evidence was found in this inquiry to support the hypothesis that entomology background, recency of university training, or the textbook used in secondary school biology classes influenced the content or method of implementing student projects. Teachers having taken a greater number of biology methods courses tended to report a higher incidence of projects involving behavior, insects, and insect behavior; teachers having taken a greater number of university biology courses reported a higher incidence of projects involving behavior; and teachers having less teaching experience reported a higher incidence of projects involving live organisms. Similar relationships were found by Dyke (1970) for the use of mammals but Anderson (1972) found no significant differences in project implementation for these variables. This inquiry supported Anderson's finding that more rural teachers than urban teachers relied on concurrent implementation and student choice of projects. However, no concurrence was found for the other variables investigated, indicating a need for further research in this respect.

Both this inquiry and Anderson's (1972) study found that the most common form projects have taken was a combination of individual and group projects. Both studies found teachers tended

to allow students to choose their own topics and tended to use the concurrent method of implementation. Fewer teachers were found to be omitting projects in this inquiry but 41.2% of the teachers were found to be devoting one week or no class time towards projects despite recommendations made by most theorists.

Objectives of least importance according to teachers in this inquiry were the objectives suggested for junior high school electives. Those objectives felt to be of highest importance were also ranked high in achievement by projects involving insect behavior. The provision of opportunities to do an in-depth study in an area of the student's interest was ranked considerably lower than in the studies by Anderson (1972), Dyke (1970), and Jacknicke (1968) but there appeared to be some contradiction in the teachers' opinions in this inquiry. The highest value of projects and the greatest advantage of projects involving insect behavior according to teachers in this inquiry appeared to be the development of the process aspects of biology. The provision for individualized instruction was also ranked high. Both the process approach and the individualized approach towards science teaching has been emphasized by recent theorists in education. The major disadvantages of projects dealing with insect behavior were felt to be the lack of proper equipment, the lack of reference material, and the extra time involved. These were also felt to be considerable problems by teachers in the studies by Anderson (1972), Dyke (1970), and Jacknicke (1968).

Although a higher proportion of teachers were found to be using live organisms in this inquiry than in the studies by Abbott

(1954), Jacknicke (1968), and Dyke (1970), the diversity of organisms utilized by each teacher and the length of time the organism was used was still low. However, in analyzing the organisms used and the topics reported for the period 1969 to 1973, it is realized that four teachers had less than four years teaching experience and that this inquiry was limited to the utilization of insects and the utilization of projects involving behavior. These factors may account at least in part for the low diversity of organisms reported. The majority of the insects reported were used in projects and collected by students. This supports Dyke's (1970) and Jacknicke's (1968) observations that the major source of live organisms has been local collection by students. In contrast to the findings by Kelly and Wray (1971) and Dyke (1970), it was found in this inquiry that organisms were used for relatively short periods of time.

Although 72.2% of the teachers in this inquiry reported the study of behavior in their classrooms, projects involving behavior accounted for a relatively low proportion of all projects conducted. The low diversity of species used by each teacher and the narrow range of topics investigated in connection with insect utilization also appeared to be the trend in the investigation of behavior and in the utilization of other organisms in this inquiry. Dyke (1970) and Jacknicke (1968) also found that teachers were using relatively few species and investigating relatively few aspects of biology. The findings from these three studies support Kelly and Wray's (1971) observation that there is a need to provide teachers with information on the nature and maintenance facility of live organisms.

CHAPTER VI

ANALYSIS AND DISCUSSION OF STUDENT INTERVIEW DATA

I. STUDENT AND PROJECT PROFILE

Of the 18 teachers contacted in September, only two requested the use of student guides on insect behavior, and of the eight students initially interested in insect behavior only one continued with the project to completion. The teachers involved indicated that the main reasons for not continuing with the projects were a lack of genuine interest in the project approach by the students and a preference for topics involving less experimental research by those students who were not biologically inclined. Fifteen of the writer's students selected projects dealing with insect behavior. However, two students changed their topic after the first month due to a lack of equipment needed in the project. Attempts were made by the students to construct alternative equipment but interest declined when these attempts failed.

The interviews conducted in December thus involved 13 of the writer's students at the Crowsnest Consolidated High School and one grade 12 student at the F.P. Walshe High School. All 14 students were girls, five enrolled in Biology 20 and nine enrolled in Biology 30. These 14 students were divided into a total of eight groups. The behavior projects conducted involved six different project topics, 10 different adult insect species, and four larval forms as indicated in Table XXII. All insects were collected locally by the students with the exception of <u>Drosophila</u>, larval <u>Musca</u>, and larval <u>Calliphora</u>.

TABLE XXII

STUDENT AND PROJECT PROFILE

STUDENT GUIDE NUMBER[a]	TITLE	SCHOOL (b)	GROUP NO.	NO. IN GROUP	GRADE	INSECT
580	General Behavior (Ant)	CCHS	1	2	12	Formica, Lasius
		CCHS	2	1	11	Formica, Thecabius
		CCHS	3	1	11	Formica
		FPW	-	1	DROPPED TOPIC	
		JTF	-	2	DROPPED TOPIC	
584	General and Mechanical Stimuli	CCHS	4	2	12	Adult and larval Dytiscus, Musca Formica, Noctuid moth
		FPW	5[c]	1	12	Adult and larval Musca
585.2	Temperature and Humidity	CCHS	6	3	11	Adult and larval Musca
		CCHS	-	2	DROPPED TOPIC	
		JTF	-	1	DROPPED TOPIC	
588	Innate Behavior	CCHS	7	2	12	Drosophila
58t	Movement	CCHS	8[d]	2	12	Adult and larval Dytiscus, Musca, adult and larval Calliphora, Coccinellid, and Curculionid
58f	Comparative Behavior (Grooming)	FPW	5[c]	1	12	Adult and larval Musca
		CCHS	8[d]	2	12	Coccinellid and Curculionid

a Adapted from the Tertiary Figure Index, Department of Entomology, University of Alberta. These guides are described in Appendix VII.

b CCHS: Crowsnest Consolidated High School
FPW: F.P. Walshe High School
JTF: J.T. Foster High School

c This group originally consisted of three students. Two dropped the topic and the remaining student investigated topics 584 and 58f.

d This group investigated portions of topics covered in guides 58t and 58f.

Drosophila were purchased from a biology supply company and *Musca* and *Calliphora* were purchased locally. Attempts were made to culture all of the insects used.

II. STUDENT OPINIONS ON PROJECTS INVOLVING INSECT BEHAVIOR

A five-point Likert scale was used to grade student opinions on the advantages and disadvantages of conducting projects involving insect behavior. Student responses were then ranked according to the total number of students that indicated the item was of high importance or of very high importance, using the same procedure as was used in the analysis of the teacher responses in this inquiry in an attempt to overcome errors of leniency and central tendency.

The main advantages of projects involving insect behavior as seen by the students in this survey were the following items: permits the student to observe and develop an appreciation for live animals (100% of the students indicating that this was of high or very high importance), allows the student to learn content of special interest (86%), and allows the student to learn content relevant to him (57%). Of least importance were the items "provides ideas for further research" (only 29% of the students indicating that this was of high or very high importance) and "allows the student to learn how to work like a scientist" (21%).

The main problems encountered by the students in this inquiry were the unavailability of adequate insects (50% of the students indicating that this was a great problem or a very great problem) and the lack of adequate library reference material (40%). The least important problems reported by these students were maintenance of

TABLE XXIII

ADVANTAGES OF PROJECTS DEALING WITH INSECT BEHAVIOR REPORTED BY STUDENTS

ADVANTAGE	NUMBER OF STUDENTS INDICATING ADVANTAGE 1 VERY LOW	2 LOW	3 MEDIUM	4 HIGH	5 VERY HIGH	TOTAL (ITEMS 4 + 5)	RANK
a. Allows the student to learn content relevant to him	2	2	2	4	4	8	3
b. Allows the student to study on his own	2	0	5	4	3	7	4.5
c. Provides ideas for further research	2	0	8	3	1	4	6
d. Permits the student to observe and develop an appreciation for live animals	0	0	0	7	7	14	1
e. Allows the student to learn how to work like a scientist	0	3	8	3	0	3	7
f. Allows the student to learn content of special interest	0	0	2	12	0	12	2
g. Allows the student to learn how to use laboratory equipment	0	4	3	2	5	7	4.5

TABLE XXIV

PROBLEMS IN CONDUCTING PROJECTS DEALING WITH INSECT BEHAVIOR REPORTED BY STUDENTS

PROBLEM	NUMBER OF STUDENTS INDICATING PROBLEM 1 VERY LITTLE	2 LITTLE	3 ME-DIUM	4 GREAT	5 VERY GREAT	TOTAL (ITEMS 4 + 5)	RANK
a. Lack of proper equipment	7	2	3	2	0	2	8.5
b. Lack of adequate space	14	0	0	0	0	0	13.5
c. Lack of adequate library reference material	2	0	6	1	5	6	2
d. Lack of sufficient biological background	2	2	6	4	0	4	4
e. Lack of interest	11	0	1	2	0	2	8.5
f. Too time consuming	8	2	2	2	0	2	8.5
g. Adequate insects were unavailable	4	1	2	3	4	7	1
h. Insects were too difficult to handle in experiments	2	4	6	2	0	2	8.5
i. Insects were too difficult to culture	5	3	4	2	0	2	8.5
j. Insects were too difficult to maintain over holidays	11	0	2	1	0	1	12
k. Practical exercises were too difficult	5	6	3	0	0	0	13.5
l. Devising your own exercises was too difficult	5	0	5	4	0	4	4
m. Project required too much work	6	6	0	2	0	2	8.5
n. Too difficult to regulate time properly	6	3	1	0	4	4	4

insects over the holidays (only seven percent of the students indicating that this was a great problem or a very great problem), lack of adequate space (zero percent), and difficulty in conducting the practical exercises (zero percent).

The comments made by the students when asked to evaluate the specific student guide they used are summarized in Table XXV. From these comments it would appear that the guides were successful in overcoming most of the problems inherent in the project method. The two main values of the guides as seen by these students were the provision of background information and the provision of guidance so that the students knew what to examine in the project. All students indicated that the materials were simple and easily obtained and that few problems were encountered in collecting and culturing the insects. The exercises suggested in the guides appeared to be within the capabilities of the students and the majority of the students indicated that the research was interesting and informative. Students also expressed a need for guidance in interpreting their findings. All students conducted one or more of the extended exercises and the majority of the students indicated that these exercises added to their understanding of the topic.

The main changes suggested by the students were mechanical changes based on the student's personal experiences with the research aspect of the guide. These changes included alternative procedures the student had devised for collecting, culturing, and experimenting with the insects and supplemental exercises that were not mentioned in the guides. The only major criticism was that the references listed in the guides were not available in the school library. Only

TABLE XXV

EVALUATION OF STUDENT GUIDES

ADVANTAGE	NO. OF STUDENTS INDICATING	CHANGE	NO. OF STUDENTS INDICATING
OVERVIEW			
1. Provides information	4		
2. Introduces and summarizes	7		
3. Indicates what to look for	6		
4. Indicates what is expected of the student	1		
THEORY NOTES			
1. Provides information	6	1. Terms are too difficult	1
2. Explains what to look for	7	2. Some sections too complicated	1
3. Makes up for lack of references	1		
MATERIALS			
1. Simple	14	1. Additional materials suggested	4
2. Easily obtained	14	2. Replacements suggested	2
COLLECTION			
1. Simple and easily conducted	6	1. Alternatives suggested	2
CULTURING			
1. Clear and easily conducted	10	1. Changes in technique suggested	5

TABLE XXV (Continued)

ADVANTAGE	NO. OF STUDENTS INDICATING	CHANGE	NO. OF STUDENTS INDICATING
PROCEDURES			
1. Experiments easily conducted	9	1. Changes in technique suggested	2
2. Instructions simple and clear	5		
3. Sequences easy to follow	2		
4. Interesting	10		
INTERPRETATION			
1. Explains what to look for	12	1. Too difficult	2
2. Keeps student on the right track	12		
EXTENDED EXERCISES			
1. Added to one's understanding	12	1. Supplemental exercises suggested	3
2. Precise and accurate	3		
3. Helps students wishing to carry on further research	1		
REFERENCES			
1. Good where available	9	1. Lacking in library, different references should be listed that are available	12

two students suggested a simplification of the content of the student guides, and all students indicated that the format and objectives of each guide should be left unchanged.

III. DISCUSSION OF STUDENT INTERVIEW DATA

The teacher interviews conducted in the spring revealed that only five projects were being conducted on insect behavior. The low number of requests for student guides dealing with insect behavior in September further indicated that this particular topic comprised only a small proportion of all projects that were being conducted. This may be due in part to a general lack of knowledge and appreciation of insects as experimental animals both on behalf of the students and the teachers involved in the inquiry. This may also be due to a tendency to conduct projects on a more theoretical basis with emphasis on library research rather than experimental research, either because of a lack of interest on behalf of the students or because of a lack of emphasis on laboratory and field research by the teacher. This tendency was noted particularly among rural teachers in the study by Anderson (1972).

The influence of a teacher's attitudes and personal interests can be seen in the higher number of students conducting projects on insect behavior in the writer's classes. Nineteen percent of the writer's students enrolled in Biology 20 and 40% of his students enrolled in Biology 30 conducted such projects although no limitations were placed on the types of projects that could be investigated nor on the types of animals or plants that could be used other than the restrictions suggested for the humane treatment of live organisms by

the Animal Welfare Institute (1960). The writer's recommendation of insects as experimental animals and his own research in the school laboratory probably accounted at least in part for the number of projects conducted on insect behavior. This transference of interest and motivation, either intrinsic or extrinsic, has been noted by various educators, including Brandwein (1962), Hale (1967), Nay and Crocker (1970), and Allen (1971).

There was a marked difference in opinions between teachers and students with respect to the advantages of projects involving insect behavior. All students felt that these projects allowed the student to observe and develop an appreciation for live animals whereas only 61% of the teachers rated this as being of high or very high importance. The learning of content of special interest and the learning of content relevant to the student were also rated higher by the students than by the teachers. However, since the students in this survey were motivated to study insect behavior to begin with, these responses probably reflected their bias and as a result these three items were likely graded higher than they would have been if the general student population had been interviewed.

Both students and teachers indicated that the provision for future research was of minor importance in these projects. The least significant advantage of projects dealing with insect behavior according to the students in this survey was the item "allows the student to learn how to work like a scientist". Only 21% of the students indicated that this was of high or very high importance. On the other hand, the corresponding item "develops skill in scientific thinking and problem-solving" was ranked highest in

importance by the teachers in the survey, 89% of the teachers indicating that this was of high or very high importance. Sixty-seven percent of the teachers also indicated that the development of scientific attitudes was a significant advantage. This disparity between student and teacher opinions may be due to a lack of understanding on behalf of the students. Students were possibly unaware of the scientific procedures and attitudes involved in the projects, or they possibly did not realize that the problem-solving exercises and the interpretations required in these guides were aspects of scientific research. This disparity also may be due to overestimation on behalf of the teachers.

In comparison with the students in this inquiry, students in the study by Foster (1970) indicated that projects allowed them to progress at their own speed and that they had learned how to study on their own. The learning of relevant content was noted as an advantage by students in the surveys by both Foster (1970) and Cowan (1967). The majority of the students in the study by Hale (1967) indicated that they enjoyed conducting projects and that they felt that they had learned worthwhile material, but a large minority of the students felt that such activities were unproductive. In the study by Anderson (1972), 46% of the students felt that learning basic techniques of plant and animal care was a considerable or very great advantage of projects. Sixty-nine percent of the students felt that learning information of special interest was a considerable or very great advantage of projects.

The main problem identified by the students in this survey was that adequate insects were unavailable, 50% of the students

indicating that this was a great or a very great problem. The insects recommended in the six projects conducted were the housefly (Musca), ant (Formica), dragonfly, diving beetle (Dytiscus), phantom midge, cricket, mealworm, milkweed bug (Oncopeltus), cockroach, Drosophila melanogaster, and Drosophila virilis. Of these, students were able to obtain houseflies, ants, diving beetles, and Drosophila melanogaster. Although other species were available, it was found that students were reluctant to attempt to obtain local insects. There were several possible reasons for this. First, with the onset of cold weather insects were more difficult to find and some students were hesitant to devote the extra time and energy needed for collection. Furthermore, students lacked the skill and background needed to locate these insects and preferred to utilize the few species that were readily available. Third, the majority of these students had not conducted projects previously or had not conducted research with live organisms. As a result, the novelty of this type of investigation and uncertainty of the techniques involved when working with live organisms delayed research in some projects, especially at the grade 12 level.

The only other major problem encountered was the lack of adequate library reference material. Although the theory notes in each of the student guides provided sufficient information for the student to conduct the project, students found it difficult to go beyond the information provided in the guide or to find information confirming or elaborating on their experimental findings. Emphasis on theoretical projects and library reports in earlier grades possibly accented this concern by the students. Using the same

method of analysis as was used in this inquiry for the findings by Anderson (1972), the lack of adequate reference material was also a major problem reported by the students, second only to difficulties involved in choosing a topic. Twenty-eight percent of the students indicated that the lack of references was a considerable or a serious problem in Anderson's study (Table XXVI).

The other problems indicated in this inquiry apply to the project method in general. Twenty-nine percent of the students indicated that lack of sufficient biological background, difficulty in devising practical exercises on their own, and difficulty in properly regulating time were problems. In the survey conducted by Foster (1970) students indicated that they had difficulty disciplining themselves, that they had to work harder when conducting projects, and that they felt some of their classmates were too immature for the responsibilities involved in such exercises. Various theorists referred to earlier have noted these operational problems and stressed the need for teacher guidance in training students to use the project method. These theorists include Richardson (1959), St. Lawrence (1968), Chancey (1968), and Thurber and Collette (1965).

Other major problems indicated by teachers surveyed in the spring included the lack of proper equipment, insufficient teacher background in collecting and culturing techniques, and the fact that projects were too time consuming (Table XXVII). None of these items were indicated as major problems by the students surveyed in the fall, supporting the writer's earlier hypothesis that these problems could be overcome by properly selected exercises and the use of student guides providing the necessary background

TABLE XXVI

COMPARISON OF PROBLEMS IN CONDUCTING PROJECTS
AS VIEWED BY STUDENTS IN TWO STUDIES

OBJECTIVE	PERCENTAGE OF STUDENTS INDICATING GREAT OR VERY GREAT PROBLEM	
	GENERAL PROJECTS Anderson	INSECT BEHAVIOR PROJECTS Franz
a. Lack of proper equipment	11.8	14.3
b. Lack of adequate space	9.6	0
c. Lack of adequate library reference material	27.9	42.9
d. Lack of sufficient background	20.5	28.6
e. Projects required too much work	23.4	14.3
f. Difficulty in choosing topic	33.6	Not Listed

TABLE XXVII

COMPARISON OF TEACHER AND STUDENT EVALUATION OF PROBLEMS IN CONDUCTING PROJECTS DEALING WITH INSECT BEHAVIOR

PROBLEM	PERCENTAGE OF INDIVIDUALS INDICATING GREAT OR VERY GREAT PROBLEM	
	TEACHERS	STUDENTS
a. Lack of proper equipment	61.1	14.3
b. Lack of adequate space	27.8	0
c. Lack of adequate library references	50	42.9
d. Student lacks sufficient biological background	44.4	28.6
e. Lack of student interest	44.4	14.3
f. Too time consuming	50	14.3
g. Adequate insects were unavailable	44.4	50
h. Insects were too difficult to handle	16.7	14.3
i. Insects were too difficult to culture	27.8	14.3
j. Insects were too difficult to maintain over holidays	38.9	7.1
k. Practical exercises were too difficult	*	0
l. Devising your own exercises was too difficult	*	28.6
m. Projects required too much work	*	14.3
n. Too difficult to regulate time properly	*	28.6
o. Classes are too large	44.4	*
p. Insufficient teacher background in collecting and culturing techniques	44.4	*
q. Inadequate knowledge of what insects are available	38.9	*

* Not Listed

information. Only one group of students experienced difficulty in obtaining proper equipment. This involved the construction of special apparatus, a thermogradient and choice chambers for studying reactions to temperature. Whereas this group eventually changed their topic, other groups using this guide avoided the problem by devising alternative exercises.

Both the students and the teachers indicated that the lack of space, difficulties in maintaining and culturing insects, and difficulty in conducting experiments with the insects were minor problems. Only 14% of the students interviewed indicated that the projects required too much work in comparison with 23% of the students in the survey by Anderson (1972). Furthermore, the evaluation of specific guides by the students indicated that few problems were encountered in the collection, culturing, or experimentation aspects of the projects. Where difficulties had arisen, students were able to go beyond the information provided and devise alternative techniques and exercises. Students also indicated that the exercises were interesting and added to their understanding of the topic and that the main values of the guides were the provision of background information and the provision of guidance in experimentation and interpretation of the results.

From these findings, it would appear that the use of insects in projects offers several distinct advantages. Little space is needed and simple and easily obtained equipment can be utilized. Insects are relatively easy to maintain, culture and experiment with, and projects dealing with insect behavior can add to the student's understanding of specific biological topics.

Such projects can also develop an understanding of and appreciation for live organisms and provide for individualized instruction in topics of special interest to the student.

The comments made by students also appear to indicate that students need assistance and encouragement in the collection of live organisms and guidance and training in using the project method. Students also need background information on the specific topic they are investigating and guidance in experimentation and interpretation of their results. The apparent success in overcoming or decreasing these problems by the student guides utilized in this inquiry would appear to indicate that projects on insect behavior can be incorporated into the current biology curriculum and contribute to the education of the student. Furthermore, the findings of this inquiry would indicate that the student's background knowledge and the student's ability for formal operational thought as proposed by Gagné (1963) and Piaget (1952) are important considerations in the implementation of the project method.

However, in the analysis of this data, there are at least two limitations on the validity of any interpretations that may be formulated. First, only 14 students were involved in the student interviews and only six of the 12 possible projects were evaluated. These interpretations can thus be generalized only to the extent that other students and projects are similar to those involved in this inquiry. Second, although the purpose of the interviews was explained to each student, the students may have been influenced by the fact that they were also being taught and evaluated by the writer. As a result, some students may have been hesitant in

suggesting changes in the student guides or more lenient in evaluating the advantages and disadvantages of their projects.

IV. SUMMARY OF STUDENT INTERVIEW DATA

The low number of requests for student guides dealing with insect behavior provided further support to the writer's observation that this topic was receiving little attention in the schools contacted. Five Biology 20 and nine Biology 30 students conducted projects involving insect behavior, utilizing six different project topics, 10 different adult insect species, and four different larval species.

The students in this inquiry indicated that the major advantages of projects dealing with insect behavior were the items "permits the student to observe and develop an appreciation for live animals" and "allows the student to learn content of special interest". The learning of content of special interest, the learning of content relevant to the student, and the development of an appreciation for live animals were all rated higher by the students in this inquiry than by the teachers. Of least importance were the items "provides ideas for further research" and "allows the student to learn how to work like a scientist". Teachers surveyed in the spring had felt that significant advantages of projects involving insect behavior were the items "develops skill in scientific thinking and problem-solving" and "develops scientific attitudes". This inconsistency between student and teacher opinions may be due to a lack of insight on the part of the students, or due to optimism on the part of the teachers.

The main problems encountered by the students in this inquiry were the unavailability of adequate insects and the lack of adequate library reference materials. It was found that students were hesitant to obtain local insects if they were not readily and easily obtainable. The lack of reference material was also felt to be a considerable problem by students in the study by Anderson (1972). Other problems suggested by teachers in the spring were not indicated as being major problems by the students in this inquiry. Both pupils and teachers indicated that lack of space, difficulty in maintaining and culturing insects, and difficulty in conducting experiments with insects were minor problems. The two main values of the student guides used were the provision of background information and the provision of guidance in experimentation and interpretation according to the students in this inquiry. All students indicated satisfaction with the format of the project guides.

From these findings, it would appear that the use of insects in projects offers several distinct advantages. From the comments made by students in this inquiry, it would also appear that students need assistance and encouragement in the collection of live organisms, guidance and training in using the project method, background information on the topic they are investigating, and guidance in experimentation and interpretation of results. The apparent success of the project guides in this inquiry would indicate that projects involving insect behavior can be incorporated into the secondary school biology program, but it is realized that this interpretation is based on a small sample of students and that it is probable that students were biased when the interviews were

conducted although the projects were graded prior to the interviews. The findings of this inquiry also indicated the importance of student background and ability in implementation of the project method, although it is realized that this interpretation is generalizable only to the extent that other projects and students are similar to those involved in this inquiry.

CHAPTER VII

UTILIZATION OF PROJECTS INVOLVING INSECT BEHAVIOR

I. RATIONALE

> There are few who would deny the need to understand more fully the roots of human behavior. The controversies aroused by Konrad Lorenz' book On Aggression and Desmond Morris' The Naked Ape reveal how little we know about this subject. This knowledge can come only from a broader knowledge of animal behavior generally than we now possess. And since behavior evolves in and is closely conditioned by the community in which an animal occurs, it is fully understandable only in an ecological context. It is this field--behavior and environment, or ethology and ecology--that is truly the science of tomorrow.

This quotation from the entomologist H.E. Evans (1970) reflects the underlying philosophy behind the projects suggested in this chapter. The prime objective arising out of this philosophy is the development of a deeper understanding of and appreciation for the living organism. Students interviewed in this inquiry indicated that this was the main advantage of conducting projects involving insect behavior, and it is the contention of the writer that a student cannot obtain a full understanding of biology without working with live organisms. To truly appreciate the process of life, a student must observe the entire creature as it interacts with its environment and fellow beasts. It is also the contention of the writer that printed pages in a text, the irritating odor of formaldehyde, and the crunch of dried specimens are not the sights, aromas, nor sounds of life. It is only by studying live organisms in the classroom and in the field that the natural interest in living

things can be nurtured and hopefully the appropriate attitudes towards them developed.

The second major objective of the projects proposed in this chapter is the development of skills in scientific thinking and problem-solving. This was the main advantage of projects involving insect behavior as seen by the teachers in this inquiry. Closely related to this are two other objectives rated high in importance by these teachers: the encouragement of attitudes of curiosity and enquiry, and the provision of practice in methods of scientific research and proper scientific reporting. These three objectives are based on the philosophy that for a better understanding of science a student should function like a scientist. This philosophy can be seen in the process, discovery, and enquiry approaches towards education. Educators such as Schwab and Brandwein (1962) and Parker and Rubin (1966) have suggested opportunities should be provided for the student to emulate research methods of scientists.

The last major objective is the provision of content that is of special interest and that is relevant to the student. These two items were rated high in importance by the students in this inquiry. Furthermore, the current biology curriculum guide for Alberta (1971) suggests one of the purposes of projects is to allow each student to do an in-depth study in an area of his interest. Many educators, from Ausubel (1964) to Postman and Weingartner (1969), have emphasized the importance of relevance and interest in learning.

Each of these objectives has been selected from teacher opinions on the advantages of using projects involving insect

behavior, or from comments made by students who have completed such projects.

II. PROJECT CONSTRUCTION AND IMPLEMENTATION

David L. Lehman (1968) outlined the following procedures for the development of laboratory and field investigations in biology courses. First, the specific teaching objectives and the content for each investigation should be operationally defined. The students for whom the investigation is being designed should then be assessed and the appropriateness of each investigation in the overall course sequence should be determined. Next, the organisms, equipment, and materials to be used should be identified. After writing a preliminary rough draft outline of the investigation, the teacher should make a trial run of the exercise and then write the student material in complete form, indicating the purpose, materials and equipment, procedures, and guidelines for interpreting the results. A teacher's guide should also be written, indicating the major ideas, suggestions for teaching the topic, and background reading. Finally, a trial run with a group of students should be made before using the project with the entire class.

These procedures, supplemented by the guidelines suggested by Gilbert Chancey (1968) for projects in distributive education, were used to develop the student and teacher guides used in this inquiry. The writer attempted to include in each student guide both incisive and generalizable knowledge to assist students in going beyond the information provided and in devising their own lines of investigation as suggested by Gagné (1963). The overall

design of these guides is summarized in the Teacher Guide to Insect Behavior Projects (Appendix VI). Student evaluation of the six guides used indicated that the format and content of the guides met their needs adequately. In particular, students indicated that the guides provided information and guidance needed for experimentation and interpretation of results.

Various authors have suggested problems that may arise in the implementation of student projects. The main authors referred to in implementing and evaluating the projects used in this inquiry were Allen (1971), Richardson and Cahoon (1951), Thurber and Collette (1965), St. Lawrence (1968), Ricard (1965), Coakley (1968), Coutant (1956), and Miller and Blaydes (1962). Valuable information can also be found in the guide for junior high school electives by the Edmonton Public School Board (1970) and the guides for secondary school biology and Science 11 by the Department of Education in Alberta (1971).

From the evaluation of the projects used in this inquiry and the writer's own experiences with these projects four main potential problems were indicated. First, some students experienced difficulty in obtaining insects. This problem was largely resolved by the students by substituting other local species that were readily available. This problem does suggest, however, that teachers may have to provide some assistance or guidance in the collection of insects. McMullen (1964) and Beirne (1963) are two valuable and inexpensive resources for teachers lacking background in the collection of insects, and Needham _et_. _al_. (1959) provides a comprehensive summary for the maintenance and culturing of most

invertebrate groups. Insects can also be purchased from the major biological supply houses, the two closest sources being Science Borealis Limited in Mississauga, Ontario, and the Northwest Biological Supply House in Victoria, British Columbia. Insect larvae, particularly mealworms and maggots, are also sold in some pet stores as fish food and in some hardware stores as fish bait.

A second problem encountered in the use of these guides was the lack of adequate library reference material. Although the essential information was provided in the student guides, students who wished to go beyond this information were unable to find appropriate references. Since the majority of the students in this inquiry were from the writer's classes, the problem was largely resolved by loaning texts from the writer's own library. The most useful references in this respect were found to be Carthy (1958), Stokes (1968), and Kalmus (1948). These three texts provide a summary of invertebrate behavior theory, specific experiments on animal behavior, and specific experiments with insects respectively.

The third problem that this inquiry revealed was the need for guidance in experimenting with live organisms and in interpreting the results of the experiments. Students who were interviewed indicated that this was one of the main values of the student guides on insect behavior. The writer also found that by providing such information in the guides, less guidance had to be provided during class time in comparison with those projects lacking such guidelines.

The fourth problem revealed was the need for guidance and training in using the project method itself. Although the use of

student guides alleviated this problem to some extent by outlining specific objectives and procedures, frequent student-teacher contact was still needed. This inquiry lends support to the previously cited research indicating that secondary school students may still be at the stage of concrete operations and that some secondary school students lack the abstract thought required for the development of hypotheses and the planning of scientific experiments.

III. INSECT BEHAVIOR TOPICS

> New lights burst forth: I received a sort of mental revelation. So there was more in science than the arranging of pretty Beetles in a cork box and giving them names and classifying them; there was something much finer: a close and loving study of insect life, the examination of the structure and especially the faculties of each species.

There are a wide variety of topics that a student can investigate at the secondary school level to reveal this nature of life referred to by Fabre (1912), the "Virgil of the insects". The following summaries are a few examples of the projects developed within the guidelines of the preceding rationale and suggestions for project implementation, with emphasis on those projects that were conducted by students as part of this inquiry.

General Behavior

Studying the general behavior of an organism not only increases our knowledge of that organism, but is essential in that it forms a basis and a reference for future investigations into all other aspects of that organism's biology. One of the most evident reasons for the study of general behavior is that through observation of the interactions of an organism with its environment and with

other forms of life, we obtain a better understanding of the entire organism. Such observations also increase our understanding of the processes of behavior, not just the behavior of the organism under investigation, but also the behavior of related species and similar forms of life. This in turn increases our knowledge of the basic principles underlying behavior, principles that explain the responses and interactions of all forms of life from the unicellular ameba to the most complex of all creatures, man himself.

Furthermore, information obtained from research on general behavior increases our understanding of the web of life and the role the organism has in it, understanding that man must have as his increasing population places greater and greater stress on the intricate interactions of nature. Indeed, through the study of general behavior we obtain evidence of various mechanisms of individual and species survival, problems that must be met by all organisms, man included.

A common project on general behavior frequently conducted by students is the study of an ant colony. Three groups of students studied ant behavior in this inquiry. One group studied the genus *Formica*, one group studied both *Formica* and *Lasius*, and one group studied the genus *Formica* and the aphid *Thecabius*. The projects involved the construction of an observation nest, analysis of the nesting material, and examination of the organization of the colony. Initial colonization, individual behavior (running, feeding, cleaning, and nest building), and social behavior (examining, licking, aggression, food sharing, greeting, and carrying) were investigated also. Where appropriate species or castes are available, this

project could also include mating behavior, egg laying, brood behavior, and slave-keeping. Extended exercises for the more interested student could include examination of sense organs involved in the behavioral responses and examination of colony movement, trail-laying behavior, and the effects of the physical environment (such as temperature, light, and humidity) on nest activity. From these observations students should be able to relate the various behavioral responses to the anatomy of the insect, to adaptations for species survival, or to both of these facets of interpretation.

Examination of the general behavior of specific species of insects was one of the most frequently reported projects on insects in the teacher interviews held in the spring. Although requiring a more sophisticated nest and some degree of caution, students could also investigate the behavior of social bees along the same lines as those suggested for ants. Students could also combine ecological and behavioral principles in a study on insect succession. One example of such a project would be the investigation of parasite and scavenger succession in cow-pats. One student in this inquiry combined the study of ant behavior with the study of aphids. Her research included an examination of running, feeding, and examining behavior patterns in the aphid besides interactions between *Formica* and *Thecabius populiconduplifolius*.

Rhythmic Behavior, Endogenous Periodicity

Rhythmic behavior refers to behavior which occurs in a regular cycle, either a long term cycle such as seasonal migration or mating or short term cycles such as daily patterns of activity and

sleep. These cycles fall under one of two categories: exogenous rhythms or endogenous rhythms. Exogenous rhythms are those which are direct responses to physical changes in the environment and are thus controlled by environmental cycles and not the organism. As such, the cycle can be altered when the organism is placed in new environments or conditions.

Endogenous rhythms are those in which responses arise from within the organism and thus are not changed when the organism is placed in new environments. This internal control mechanism is termed a "biological clock", but how it operates is still largely unknown. Some theorists claim the clock is "set" by external stimuli, others claim that it is controlled by the heredity of the organism. One area receiving considerable attention by behaviorists is that dealing with circadian rhythms, endogenous rhythms having a periodicity of approximately 24 hours.

Most experiments on rhythmic behavior in insects involve complicated equipment or periods of time extending beyond that usually devoted towards student projects. One exception is the study of rhythmic behavior in the milkweed bug Oncopeltus. One group of insects can be raised from eggs under a photoperiod of 16 hours light and eight hours darkness while a second group can be raised under 10 hours of light and 14 hours of darkness with the temperature being between 25 and 35 degrees Centigrade. Mating, feeding, and oviposition behaviors of the two groups are then compared. This requires observations at two to four hour intervals to note the types of movements, frequency of occurrence, and percentage of insects involved for each activity. By placing half the insects under

constant dark and half under constant light and repeating these observations, students can also determine if the rhythms observed are endogenous or exogenous.

<u>Orientation, Kineses and Taxes in General</u>

Behavior is the result of information received by the organism from both its external and its internal environments. That is, it receives stimuli from both its surroundings and from its own body. Responses to these stimuli are of three types. Tropisms are nonlocomotory responses in which the organism bends towards the stimulus. Tropisms are usually used in reference to plants and sessile animals. Kineses are undirected locomotory reactions in which the rate of movement or the frequency of turning depends on the intensity of the stimulus (Thorpe, 1963). Taxes are directed locomotory reactions towards, away from, or at a constant angle to the stimulus. A movement towards a stimulus is called a positive taxis, a movement away from the stimulus is called a negative taxis.

Almost any insect can be used to investigate responses to physical stimuli, but species capable of perceiving a variety of stimuli and having distinct behavioral responses make better experimental subjects. Noctuid moths are particularly suitable in these respects and the writer has had moderate success with both adult and larval forms. Thigmokineses can be investigated simply by touching adults and caterpillars with a blunt probe, using different degrees of pressure and different lengths of contact. A whistle, tuning fork, or oscilloscope can be used to investigate responses to sound. Orientation and locomotor patterns in response to gravity

can be studied in the caterpillar simply by balancing it on a board covered with fine-grain sandpaper held at different angles.

Olfaction can be studied by placing the insects in a glass jar connected to two other jars as illustrated in Figure 1. Possible test substances include local flowers, crushed fruit, and perfumes. Contact perception (taste) can be studied by suspending the moth and touching the tarsus of one of the forelegs with molar solutions of sucrose, gradually increasing the molarity until a response is produced. To investigate thermotaxes or hydrotaxes choice chambers or gradients are required. These can either be purchased by the school or constructed by the student. Several possible designs are illustrated in Figures 2 to 4. Phototaxes can be studied by placing the insects in an observation tray such as a dissecting pan or an aquarium. Half the tray is covered with black construction paper and the other half is exposed to a light source. Students can then observe the movements of the insects under these two conditions and the final distribution of insects after a specific period of time.

Reactions and Responses to General and Mechanical Stimuli

The mechanical stimuli are those of gravity, pressure, sound, and touch. The sense organs that receive these stimuli are known as mechanoreceptors. Almost any species of insect can be used to investigate this aspect of behavior. The insects recommended in the student guide devised by the writer were diving beetles (*Dytiscus*), houseflies (*Musca*), and dragonflies. Two groups of students investigated responses to mechanical stimuli in this inquiry. One group used adult and larval *Musca* and one group used adult and larval

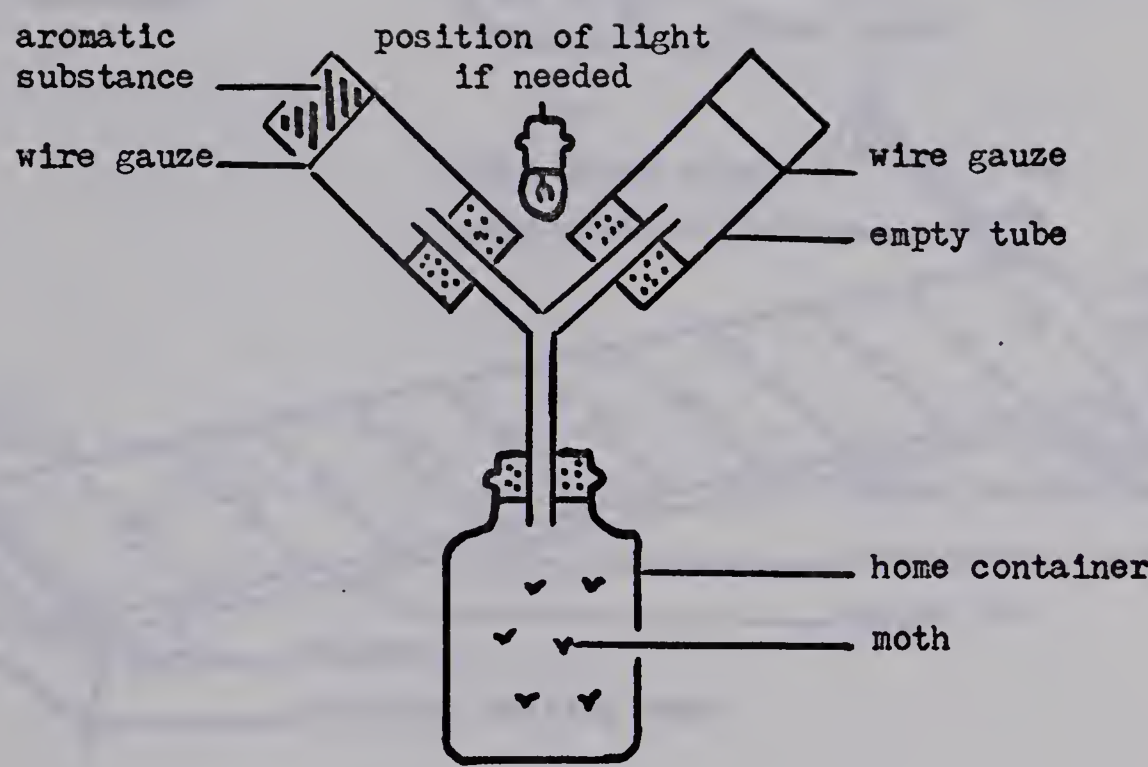


FIGURE 1

OLFACTORY CHOICE CHAMBER

The apparatus is clamped in a vertical position for flying insects or laid flat for walking insects. The light may be used to attract positively phototactic insects for quicker results. (From Hainsworth, 1967.)

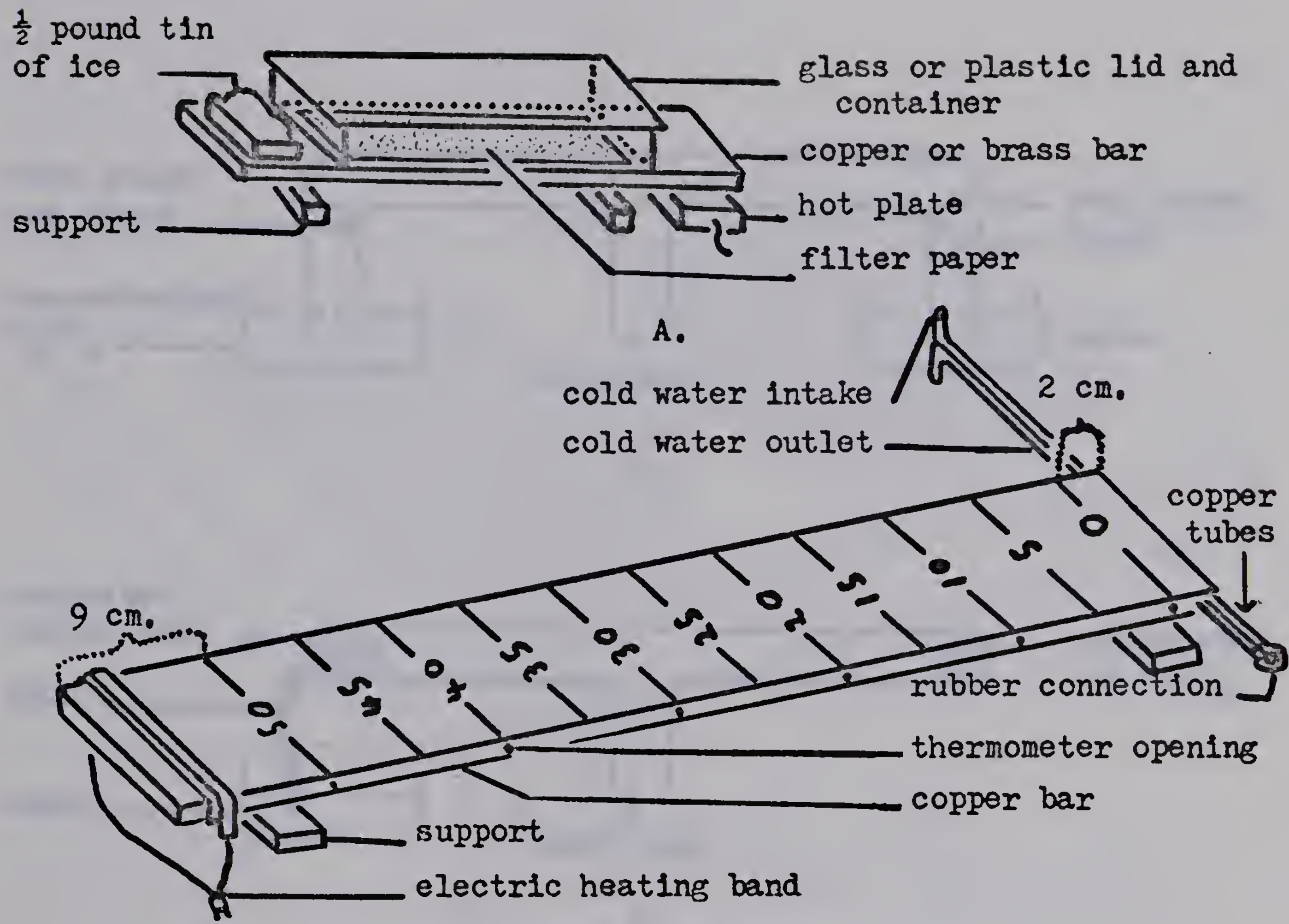
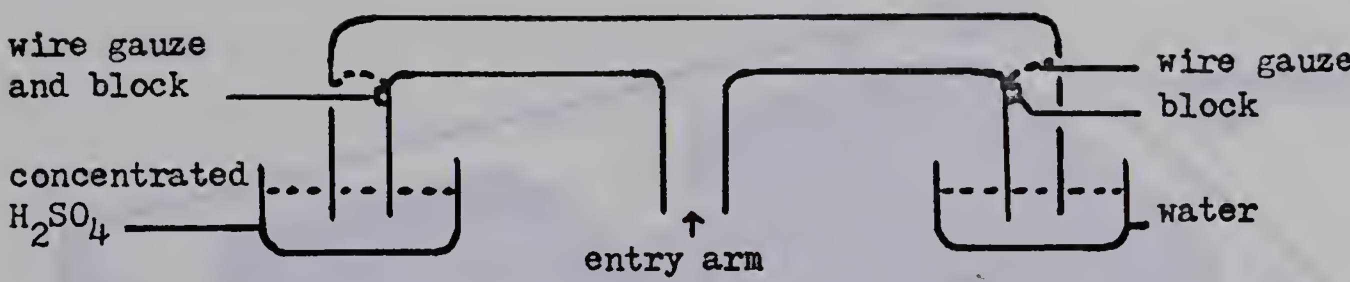


FIGURE 2

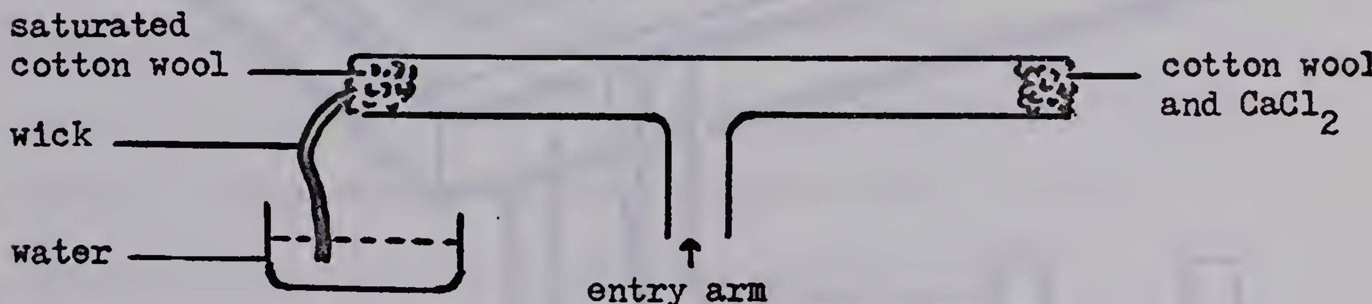
TEMPERATURE GRADIENTS

A. Copper or brass bar measures 1" x 2" x 15". After 10 minutes the temperature is recorded every two inches along the bar by setting the bulb of the thermometer on the bar. (Described by Kalmus, 1948.)

B. Copper bar is 1.2 cm. x 10 cm. x 61 cm. The copper bar is graded in centimeters with openings for thermometer readings at even numbers on one side and at odd numbers on the other side. Copper tubes are 30 cm. long with 9 mm. O.D. and 6 mm. I.D. Copper tube is connected to a cold water source. The heating band is connected to a regulator. Insects are placed in a glass or plastic container above the bar. (Used by the Department of Entomology, University of Alberta.) After W.G. Evans.



A.



B.

FIGURE 3

HUMIDITY GRADIENTS

A. E-tube (From Hainsworth, 1967.)

B. T-tube (From Hainsworth, 1967.)

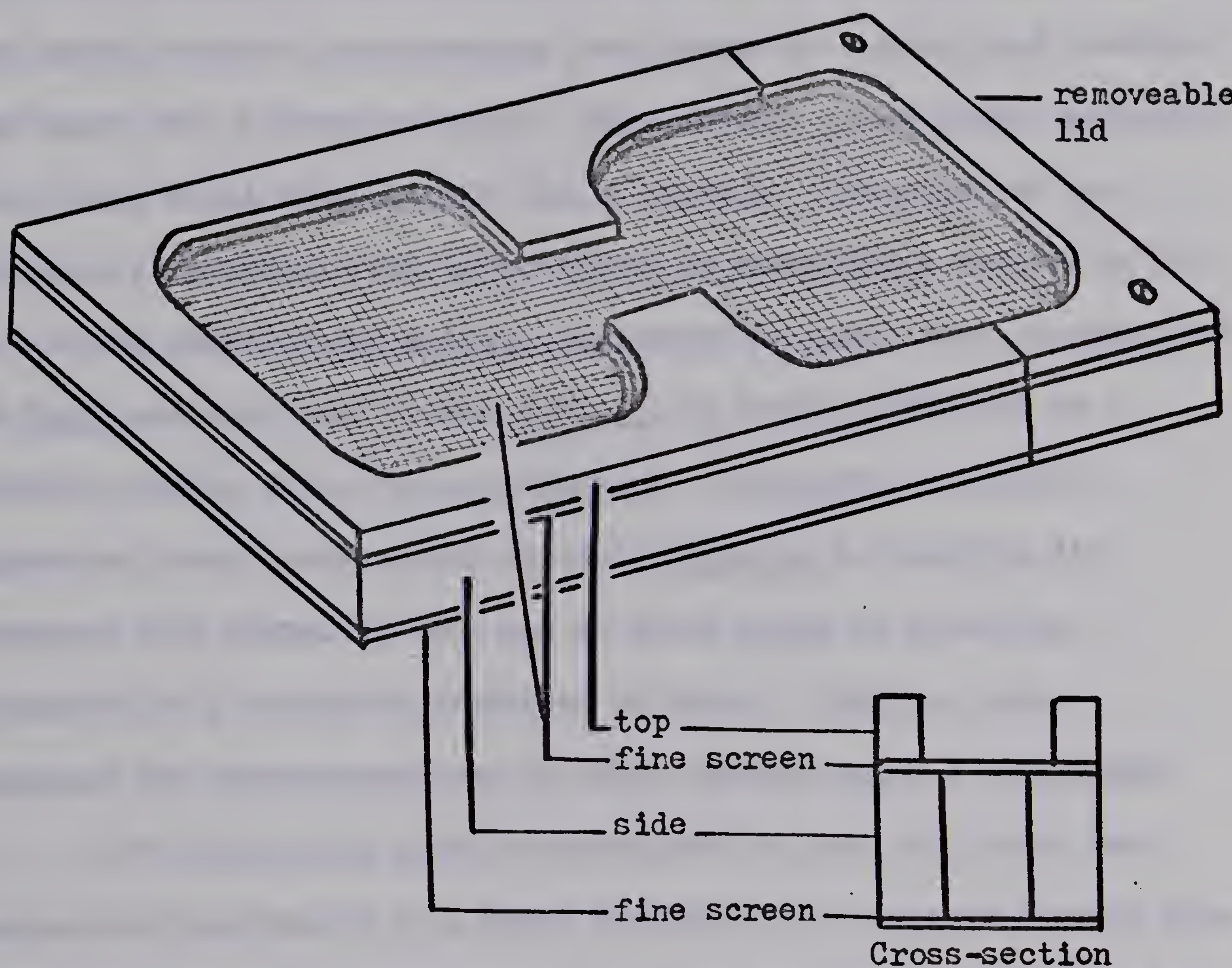


FIGURE 4

CHOICE CHAMBER

Constructed of plywood and fine screen, 230 mm. x 120 mm. x 25 mm. with a removeable lid 120 mm. x 50 mm. Openings are 105 mm. in diameter and 7 mm. apart. Insects are placed between the two screens and the chamber is placed over the stimuli (such as petri dishes of water and sulfuric acid). (Used by the Department of Entomology, University of Alberta.) After W.G. Evans.

Dytiscus, Musca, Formica, and Noctuid moths.

In addition to investigating responses to touch in these insects, students also investigated the relationship between flight and tarsal contact by suspending the insects on a match and touching the tarsi with a sheet of paper. Many insects cease flight movements once their tarsi make contact with a surface. Responses to air currents (rheotaxes) were investigated by directing a current of air to various parts of the insect. Responses to sound were investigated in Musca and adult and larval Dytiscus by noting responses to a whistle, tuning fork, and oscilloscope. Responses to gravity (geotaxes) were investigated in adult Dytiscus by altering its buoyancy with pieces of cork and in adult Musca by observing movements in a stoppered graduated cylinder. Students also examined the mechanoreceptors of these insects under a microscope.

The only major problem encountered by the two groups was suspending the insects on a match with wax. The insects usually came out of the ether before the wax had hardened. Fast drying glues such as those used in making model airplanes were used as an alternative but the insects had to be destroyed after experimentation.

Reactions and Responses to Chemical Stimuli

The structures receiving chemical stimuli, collectively known as chemoreceptors, can be distance receptors for olfaction or contact receptors for taste. These chemoreceptors are chemically sensitive cells or sensory hairs (sensilla). Insects with mouthparts modified as a proboscis such as in the housefly or butterfly unfold or unroll the proboscis preparatory to feeding. This response makes

them particularly suitable for experiments on contact perception. The Monarch butterfly (Danaus) was recommended in this project. Conditioning, threshold levels, and summation of stimuli can be investigated for various chemical solutions by following the procedure described for sucrose on page 148. Comparisons can also be made between insects which have been fed only distilled water for different intervals of time prior to experimentation.

Olfaction can be investigated by using the choice chambers illustrated in Figure 1 or Figure 4. Monarch butterfly larvae feed on leaves from the milkweed (Asclepias). Responses to these leaves can be investigated in comparison with other local leaves or in comparison with milkweed leaves treated with perfume, turpentine, sodium chloride, or methyl alcohol. The more interested student can examine the chemoreceptors and attempt to classify the responses observed. Responses to water could also be investigated under this topic. Some of the more specific studies that might be conducted at the secondary school level include odor perception in honeybees, sexual attraction in Saturniid moths, and alarm reactions and trail-laying in ants.

Reactions and Responses to Temperature and Humidity

The sense organs receiving stimuli which result in responses to temperature are collectively known as mechanoreceptors. Humidity differences, on the other hand, can cause changes in the physical properties of structures and thus stimulate mechanoreceptors, or they can cause chemical changes and thus stimulate chemoreceptors. To investigate these two aspects of the environment, insects are placed

on the gradients illustrated in Figure 2 and Figure 3 and their initial movements are recorded. Besides the number of insects at each point on the gradient over a series of time intervals, students can record the number of right and left turns if a choice is provided for the insect. The housefly (Musca) was recommended for this project.

One group of students completed this project. The major problem encountered was obtaining a thermogradient, both due to a lack of materials in the school and a lack of technical ability in construction of the equipment on behalf of the girls involved. No suitable alternative to the equipment illustrated in Figure 2 could be found and as a result one of the two groups beginning this investigation decided to change their topic. The other group of students modified their investigation by studying the movement of Musca larvae on three by five inch copper plates which had been heated or cooled to specific temperatures. The responses of adults were investigated under constant temperatures by using an incubator and a refrigerator. Students also attempted to study the direction of movement and speed of Musca larvae by cooling one end of a glass plate with ice and by heating one end with an electric hotplate. Besides studying responses to humidity as described on the preceding page, students also examined the thermoreceptors and hydroreceptors of the housefly.

Reactions and Responses to Visual Stimuli and Radiant Heat

Each property of light provides specific information to the insect, and as such, each property provides a stimulus differing in

behavioral significance from the stimuli resulting from other properties. Most animals react to only one or two of these properties at any one time. Behavioral responses can thus be reactions to the intensity of light, the direction of light, wavelengths, polarized light, reflected light, radiant heat, or any combination of these six properties. The project designed for this topic covered only the first three aspects of light and recommended using larval blowflies (*Lucilia* or *Calliphora*) and backswimmers (*Notonecta*).

Reactions and responses to light can be investigated by placing insects in an observation tray and exposing half of the tray to light while covering the other half with black construction paper. The types of movement, the structures used in locomotion, and the final distribution can then be studied. The effect of wavelength can be investigated by covering the tray with colored cellophane or by using photographic filters. By placing the insects in a beam of light from a desk lamp, students can investigate responses to the intensity and direction of light. Using intersecting beams from two lamps placed at different distances and angles from the insect, the student can determine if reactions are due to the intensity or the direction of the light. The time taken for habituation to the stimulus and the time taken for recovery can also be investigated.

Students wishing a more detailed analysis of this aspect of behavior could also experiment with insects which have been blinded by painting the eyes with varnish. Students could also investigate reactions to shadows and dorsal and ventral light reactions in the backswimmer. Insects can be preadapted to light or dark prior to

experimentation and the responses of insects preadapted for various lengths of time can be compared. More elaborate experiments going beyond the information in the student guide could include light compass reactions in beetles; perception of color in bees; and the perception of form, movement, and patterns in almost any insect.

Learning

Behavior patterns can be innate or learned. Innate behavior is unchanged by learning and is probably based on inheritance. Innate behavior includes kineses, taxes, and instincts. Learned behavior is based on experience and thus differs from individual to individual. Since experience and heredity interact in producing a response, many behavior patterns are due to a combination of both factors. Thorpe (1963) has classified learning into the following basic categories:

1. Habituation: an activity of the central nervous system whereby there is a relatively permanent decrease in responsiveness to repeated stimulation of constant intensity. This stimulus is relatively simple and is repeated for a relatively long time without unfavorable results.
2. Classical conditioning: the association of an indifferent stimulus (one not usually associated with the response) with an unconditioned stimulus which produces a conditioned response. If the two stimuli are repeatedly applied in overlapping sequence, either stimulus will elicit the response of the other in time.
3. Trial and error learning: the association of an indifferent stimulus after a response has been made. Thorpe notes that

trial and error learning is a form of conditioning in which the stimulus becomes associated with the response due to a retroactive influence exerted by a reward.

4. Latent learning: the acquisition of information that has no immediate function but memory of this information subsequently influences behavior.

5. Insight learning: the sudden adaptive reorganization of experience or the sudden production of a new adaptive response that has occurred too quickly to have been arrived at by random trial and error learning.

6. Imprinting: a unique learning process in which young develop an association with others during a sensitive period.

Although Thorpe (1963) and Meglitsch (1967) cite examples of learning in insects similar to insight and imprinting, whether insects can learn by these two methods is still uncertain. In the project designed for this topic, conditioning in the mealworm *Tenebrio* is investigated. The mealworm is placed in the alley of a T-maze and a light is focused on it from behind. If the mealworm turns into the right alley, the light is shut off and the insect is allowed to remain in the dark for a minute. If it turns into the left alley, the student can either focus the flashlight on the insect until it enters the right alley or only until the insect begins to turn. These are known as correctional and noncorrectional procedures respectively.

This exercise is counterbalanced by having an equal number of larvae choose the left arm as the correct response. Eight to 10 trials are conducted each session. Polt (1971) suggests that the criterion for learning would be 17 correct responses out of 20.

Students wishing a more detailed study on learning can use two groups of insects and compare correctional and noncorrectional procedures, or they can use different intensities of light. Multiple cues can be studied by placing fine-grain sandpaper under one of the arms besides using the light as a stimulus. Larvae might also be raised to determine if the learned behavior is retained as an adult.

Psychic Phenomena, Instinct and Innate Behavior

Innate behavior includes predetermined reactions to stimuli and includes kineses and taxes. Thorpe (1963) suggested that instinct refers to behavior patterns characterized by the following traits:

1. Instinct consists of an internal drive that differs from psychological needs but whose operation is largely unknown.
2. Instinct is innate in the sense that it is an inherited system of coordination.
3. Instinct involves relatively rigid inherited behavioral responses which are common to all members of a species.
4. Instinct involves relatively rigid inherited releasing mechanisms such as hormones or nerve impulses.
5. Instinctive actions are usually initiated by complex environmental situations.

Manning (1971) suggested that instinct can be initiated by simple environmental stimuli and he proposed that the organism responds to only one part of a complex situation.

The project covering this topic was designed to investigate the reproductive behavior of the fruit fly with reference to the role of reproductive behavior as an isolating mechanism in the process of

speciation. One group of students conducted this project in this inquiry. Two major problems were encountered. Students were able to obtain only one species of Drosophila and as such were able to investigate the reproductive patterns but not their role in isolation. Two different genotypes could have been used instead, but students ran out of time before a second genotype could be ordered. Research was also delayed due to frequent contamination of the culture media by mold. Much time was lost in sterilizing the equipment and establishing uncontaminated cultures.

In this project the sequence, qualitative aspects, and quantitative aspects of the various reproductive movements of the male and female were examined. These movements should then be compared with the movements in a different species and then to the behavioral responses between males of one species and females of the other species. To determine the role of reproduction in isolation, ten males and ten females of each species should be placed in an observation cage and the frequency and types of copulas recorded. By recording the frequency of couplings between like species and between different species and then comparing this with the behavior patterns of each species, students should be able to determine the degree of isolation between the two species.

Coordinated Behavior

Coordinated behavior consists of a series of simpler reactions and responses related to each other to result in a unified act or behavior pattern. The study of coordinated behavior consists of four major aspects: the control of the behavior, the variability of the

behavior, the component responses making up the integrated processes, and the result or product of the completed act.

The project outlined for this topic was the study of construction behavior in larval caddis flies. Besides examining the process of case construction and the anatomical structures used in building the larval cases, students could examine the ability of larvae to recognize their cases, the ability to repair the case, and the ability to use materials other than those found in the larva's natural environment. The types of cases built and the procedures used by different species could also be investigated. The project could be extended to include an examination of behavior patterns related to the use of the case.

Other types of coordinated behavior that might be investigated in insects include aggression and territoriality in crickets, communication in orthoptera, communication in bees, and social behavior. Mating and feeding behaviors could also be studied in almost any insect.

Movement

The project designed to cover this topic involved the locomotion of the cockroach on land, the phantom midge in water, and the fly in air. One group of students conducted this project, using the housefly (Musca), adult and larval diving beetles (Dytiscus), the ladybird beetle (Family Coccinellidae), the weevil (subfamily Curculioninae), and adult and larval blowflies (Calliphora).

Movement on land was investigated by examining the walking and climbing movements of the weevil and ladybird beetle. By cooling

the insects in the refrigerator, students were able to examine the sequence of leg movements for both species. The method by which the weevil was able to upright itself when turned over on its dorsal surface, the movement of the weevil in response to air currents, and the movement of the ladybird beetle in response to gravity were also investigated.

Swimming movements were examined with the adult and larval diving beetles under room conditions and by slowing the insects down with ether and lower temperatures. Differences in speed and stride intervals were determined for both terrestrial and aquatic species. The role of specific gravity was investigated by placing the adult and larval diving beetles in sugar solutions and the role of pressure was investigated by placing them in a graduated cylinder sealed with a rubber membrane to change the pressure. Movements in response to sound were also investigated.

Flight was investigated by suspending the housefly and the blowfly on a string and noting the effect of tarsal contact on wing movement as described on page 153. The effect of air currents on the direction of flight, the duration of flight movements, methods of commencing flight, and methods of landing were also investigated. The pattern of wing movement was studied by using a stroboflash. With the light flashing at a frequency slightly faster than the frequency of the wingbeat, the wings appeared to move in slow motion. This allowed the students to examine the pattern of movement and changes in wing inclination.

Comparative Behavior Studies

An analysis of behavior patterns exhibited by different groups can emphasize any one or more of the following purposes:

1. To establish guidelines for generalization of concepts.
2. To determine the relationship between structure and function.
3. To determine the degree of similarity between groups and thus their possible taxonomic and evolutionary relationships.
4. To determine the role of the habitat and adaptation.
5. To determine the relationship between components in a behavior pattern.
6. To determine the control of the behavior pattern.

The project designed to illustrate this aspect of behavior was based on experiments on grooming behavior conducted earlier by the writer. The recommended insects were the American cockroach, German cockroach, house cricket, mealworm beetle, milkweed bug, and the housefly. One student investigated this topic, using the housefly (*Musca*) and emphasizing purposes two and four above. The insect was cooled in the refrigerator and then covered with chalk dust. The structures used in cleaning; the sequence, frequency, and duration of each movement; and the thoroughness of cleaning were recorded. In interpreting these observations, the student attempted to relate the anatomical structures and their functions. She also attempted to relate the entire behavior pattern to the habitat and the other life processes of the insect.

The student also supplemented these observations by investigating the reactions and responses of adult and larval houseflies to general and mechanical stimuli as described on page

148. Almost any of the preceding sections can be modified into a comparative behavior study by changing the emphasis of the interpretation to achieve the purposes listed on the preceding page. The group of students studying insect movement also investigated grooming behavior with emphasis on the component stages of the behavior pattern. Cleaning movements in the weevil and the ladybird beetle were compared by this group.

IV. COLLECTING AND CULTURING INSECTS

Needham (1959) suggests there are four basic requirements for successful culturing of animals. These requirements are the provision of food, protection from enemies, a suitable physical environment to maintain the individual and successive generations, and suitable conditions for reproduction. To provide these necessities, the teacher or student must have some knowledge of the natural habitat and life history of the organism that is being cultured. There are numerous references available to assist the teacher in the collection and culturing of insects (Appendix XI).

In this inquiry 10 insect species were maintained by students (Table XXVIII). An average of two cultures were maintained for each species with an average of 12 insects per culture. The insects were maintained from two to 12 weeks and four species were raised from the larval stage. The following procedures are those used by the students in this inquiry.

Calliphora (Blowfly)

One group of students purchased a dozen blowfly larvae from

TABLE XXVIII

INSECTS COLLECTED AND CULTURED FOR STUDENT PROJECTS

INSECT	STAGE	AVERAGE NO. OF CULTURES	AV. NO. OF INDIVIDUALS PER CULTURE	LENGTH OF MAINTENANCE (WEEKS)
Calliphora (Blowfly)	From larva to adult	1	12	6
Coccinellid (Ladybird)	Adult	1	2	8
Curculionid (Weevil)	Adult	1	2	8
Drosophila melanogaster (Fruit Fly)	From larva to adult	5	25	12
Dytiscus (Water Beetle)	From larva to adult	2	3	8
Formica (Ant)	Adult	3	20	12
Lasius (Ant)	Adult	1	20	4
Musca domestica (Housefly)	Adult	2	4	2
	Larva to adult	5	18	6
Noctuid (Moth)	Adult	1	2	2
Thecabius populiconduplifolius (Aphid)	Adult	1	15	4

a local hardware store. The larvae were maintained on fresh beef liver in a one-pint culture bowl containing two inches of sawdust. The culture bowl was covered with cheesecloth at first but when the larvae escaped through the cheesecloth it was replaced with a fine mesh screen. The sawdust was moistened and the liver replaced daily. The larvae began to pupate in the sawdust three days after being purchased. Adults began to emerge 18 days after the larvae had been purchased and within 20 days all 12 larvae had pupated. The adults were fed a solution consisting of 50% milk and 50% water for approximately three weeks. By this time the students had completed their project and the blowflies were disposed of.

<u>Coccinellid and Curculionid Beetles</u>

Two ladybird beetles (Family Coccinellidae) and two weevils (Family Curculionidae, subfamily Curculioninae) were collected locally. Since the species and host plants were unknown, these insects were maintained on sugar water and housed in separate jars containing geranium leaves to provide the insects foliage in which to hide. Both species were maintained successfully for the duration of the projects.

<u>Drosophila melanogaster (Fruit Fly)</u>

One group of students purchased fruit flies from a commercial supply house. The fruit flies were cultured in half-pint milk bottles containing one inch of media. The media was made by heating 175 milliliters of distilled water, 20 milliliters of corn syrup, and 2.5 milliliters of Bacto-Agar until the mixture was clear. To this was added 35 grams of corn meal, 100 milliliters of distilled water, and

0.4 grams of sodium propionate. The media was heated further until it began to thicken and it was then poured into the culture bottles.

Five cultures were maintained continuously for approximately 12 weeks. The adults were fed daily with a few drops of suspension consisting of 10 grams of yeast, 10 grams of glucose, and 90 milliliters of distilled water. The only problem encountered in culturing these insects was contamination of the media by mold. It was necessary to sterilize the culture bottles before this problem was overcome. One culture was maintained after the projects were completed for student use in the spring semester. Increasing the amount of mold inhibitor (sodium propionate) to 1.6 grams delayed the formation of mold by at least three weeks in these cultures.

Dytiscus (Diving Beetle)

Two groups of students collected diving beetles from local ponds by using dip nets made by the students from heavy wire and canvas. Two larvae and three adults were collected. The adults were maintained in a half-gallon battery jar containing pond water and fed commercial goldfish food. The three adults died after approximately six weeks. Since diving beetle larvae are carnivorous, they were maintained in two separate jars of pond water. They were fed locally collected fresh-water crustacea and both developed into adults after approximately one month. These were maintained for an additional month before they died.

<u>Formica</u> and <u>Lascius</u> (Ants)

Three groups of students studied the genus <u>Formica</u>, each group maintaining a culture of approximately 20 ants for a period of 12 weeks. Although it was suggested in the student guides that all stages should be collected, students obtained only adult specimens. One group of students used a commercial formicarium, one used a goldfish bowl approximately half a gallon in size, and one constructed a nest from two sheets of plate glass and plywood. The nests were darkened with black construction paper. Drinking water was provided by using several sections of moistened sponge. Food included dead houseflies; fresh apples and bananas; and a diet consisting of equal parts of sugar, egg white, and melted butter.

Students found that the main problems encountered in raising the ants were dehydration of the nest and the development of mold where the prepared diet had soaked into the nesting material. Attempts to resolve this problem by providing the food in shallow dishes was unsuccessful since the ants overturned the containers. Saturating pieces of bread with this solution was found to be a more successful technique provided that excess food was removed periodically. At the conclusion of their projects, two groups of students continued to maintain their cultures at home. The third culture was maintained by the writer until the spring semester and it was then utilized by a group of students studying learning behavior.

One group of students studying the general behavior of <u>Formica</u> also attempted to study the general behavior of <u>Lasius</u>. Approximately 20 adults were housed in a commercial formicarium but all died within four weeks. This may possibly have been due to

dehydration or starvation since the students were negligent in feeding the insects and maintaining the humidity of the nest.

Musca domestica (Housefly)

Two groups of students maintained adult houseflies and two groups of students raised houseflies from the larval stage. The larvae and culture media were purchased from local hardware stores. The larvae were maintained in half-pint culture bowls covered with cheesecloth. One group of students incubated the culture at 80 degrees Fahrenheit. Only four out of the 12 larvae developed into adults after 11 days of incubation, possibly because the medium dried out too quickly in the incubator. Both groups of students maintained two cultures at room temperature (approximately 70 degrees Fahrenheit). Each culture contained approximately 18 larvae and all pupated within 18 days.

The adult houseflies were housed in half-gallon battery jars half-filled with sawdust. They were fed a solution consisting of 50% milk and 50% water. No eggs were obtained during the time the adults were maintained. Since the diluted milk quickly turned sour and had to be replaced daily, the flies were disposed of as soon as the students completed their experiments. The only problem encountered in raising houseflies was in transferring them from the stock bottles. The escape of flies can be avoided by raising the adults in quart milk bottles covered with black construction paper. Since houseflies are positively phototactic, they can be attracted into a collecting jar with a light. A damper could be placed between the stock bottle and the collecting jar to make this transfer easier.

<u>Noctuid Moth</u>

Two moths (Family Noctuidae) were collected by one group of students. The insects were maintained on sugar water and housed in a half-gallon battery jar containing geranium leaves to provide the insects foliage in which to hide. The moths were maintained for only two weeks, both becoming casualties in subsequent experiments when students attempted to suspend them on threads with melted wax.

<u>Thecabius populiconduplifolius</u> (<u>Poplar Aphid</u>)

One student attempted to study aphids in connection with her study of ant behavior. Deer Ivy plants containing aphids were placed in a cardboard box beside the ant nest with runways provided between the nest and the potted plants. All 15 aphids died within four weeks, possibly due to the lack of an appropriate host plant. It is noted in Needham (1959) that no artificial method for feeding aphids has been found.

V. RECOMMENDATIONS

The ultimate goal of this inquiry as indicated on page 4 was to formulate recommendations on the implementation and organization of projects dealing with insect behavior to assist teachers in the utilization of living organisms in their classroom instruction. From the information obtained in the interviews with teachers and with students, and from the implementation of such projects, the writer would propose the following recommendations.

First, teachers should have a clear set of objectives for conducting projects and these objectives should be made clear to the

students. The five major objectives found to be most important by the students conducting projects on insect behavior or found to be most frequently achieved by these students are indicated in the first section of this chapter.

Second, the objectives of each particular topic under investigation should be clearly stated so that the student is aware of the purpose and the nature of his investigation. It was found in this inquiry that these objectives could be incorporated into the overview summarizing the content of the student guide.

Third, to ensure that students have given some forethought to the selection of their topics, a selection form requiring the student to prepare a preliminary outline of his project should be used. By completing such a form the student is made aware of the potential problem areas in his research. Furthermore, teachers can determine if the student understands the objectives of the project and if the student is aware of the teacher's expectations.

Fourth, student guides should be provided for each topic being investigated. Contained in the guide should be a summary of the background theory, an outline of initial procedures, and suggested lines of interpretation. Students in this inquiry indicated that this was the greatest value of the student guides and the writer found that less assistance had to be given during class time to students who used such guides.

Fifth, students should be given some guidance in using the project method, particularly if this approach is new to them. Training and experience are necessary for the student to learn how to regulate time to advantage and to learn how to conduct valid research

in the laboratory or in the field. Both Gagné (1963) and Kilpatrick (1935) have noted this need for guidance if students are to conduct investigative projects. Piaget (1952) has noted the importance of considering the development of investigative ability in the child, and Inhelder and Piaget (1958) have indicated that the age at which this ability occurs is variable.

Sixth, students need assistance and encouragement in the collection and utilization of local organisms. Teachers should alert students to possible sources of live organisms and to particular techniques for collection, or the school library should contain appropriate reference texts outlining such information.

Seventh, teachers should ensure that adequate library reference materials are available to the student before the project is begun, especially if the student is conducting projects for the first time. Although the background theory provided in the student guides alleviated this problem to some extent, it was found that additional references were needed for the more interested students. It was also found that students who were more skilled and confident in the research aspects of the project method had less need for supplemental information.

Eighth, the organisms used in projects should be readily available, easy to maintain and culture, and easy to experiment with. Furthermore, the responses of the organism should be relatively simple and within the student's ability to interpret. Students in this inquiry indicated that insects met all of these requirements. Those that are particularly suitable for investigating behavior have been indicated earlier in this chapter.

Ninth, the experiments to be conducted should be relatively simple and within the student's ability to conduct and to interpret. Unsophisticated equipment and a minimum amount of space should be required in such experiments. From the findings of this inquiry projects on insect behavior appear to meet these requirements well. Few problems in experimentation and interpretation were encountered in the six topics investigated by the students in this inquiry. The exercises which in the view of the writer can be conducted at the secondary school level with a minimum of difficulty have been outlined in this chapter.

VI. SUMMARY OF PROJECT UTILIZATION

The five main objectives of projects dealing with insect behavior as seen by the teachers and students interviewed in this inquiry were the following items: the development of a deeper understanding of and appreciation for the living organism, the development of skills in scientific thinking and problem-solving, the encouragement of attitudes of curiosity and enquiry, the provision of practice in methods of scientific research and proper scientific reporting, and the provision of content that is of special interest and that is relevant to the student. The procedures used for developing student guides in an attempt to meet these objectives are outlined in this chapter. The format of these guides is summarized in Appendix VI.

From the implementation of six of these guides, four main potential problems were identified by the writer. These problems were difficulties in initiating student collection of insects, the

lack of adequate library reference materials, the need for guidance in experimentation with live organisms and interpretation of the results of experiments, and the need for guidance and training in using the project method. Suggestions for overcoming these problems are offered in this chapter and 12 sample projects are summarized. The 12 topics covered are general behavior; rhythmic behavior, endogenous periodicity; orientation, kineses and taxes in general; reactions and responses to general and mechanical stimuli; reactions and responses to chemical stimuli; reactions and responses to temperature and humidity; reactions and responses to visual stimuli and radiant heat; psychic phenomena, instinct, and innate behavior; coordinated behavior; movement; and, comparative behavior studies. The culturing methods used by students for the 10 species of insects used in this inquiry are summarized. From the implementation of these projects, nine recommendations on the implementation and organization of projects involving insect behavior are offered.

CHAPTER VIII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY OF PROCEDURES AND FINDINGS

Extent and Nature of Project Utilization

Eighteen secondary school biology teachers in southwestern Alberta were interviewed between April 30 and May 4, 1973. From these interviews it was found that teachers with a greater number of biology methods courses in their university background were more likely to have students studying behavior, insects, and insect behavior than teachers with fewer methods courses. This study also found a greater percentage of projects dealing with behavior among teachers with a greater number of university biology courses. Teachers with less teaching experience were found to have a greater percentage of projects dealing with live organisms and were found to devote more extreme amounts of class time towards projects than teachers with more experience.

Those teachers teaching a fewer number of classes tended to have fewer projects dealing with behavior whereas those with smaller class sizes had more projects dealing with both behavior and insects. A greater proportion of rural teachers than urban teachers were found to be using the project method. Rural teachers were found to have a greater percentage of students using projects dealing with behavior, insects, and insect behavior. Although some of these findings were in agreement with the findings of previous studies, the small size of the teacher population in this inquiry prevents the writer from

forming any conclusive generalizations concerning these variables.

The most common form projects took in this inquiry was found to be a combination of individual and group projects. Only one teacher did not utilize projects in all three grades. One teacher used the project method in Biology 30 but not in Biology 10 and 20 and one teacher used the project method in Biology 10 and 30 but not in Biology 20. No teachers in this inquiry relied on their own choice of topics exclusively and 64.3% of the teachers allowed their students to choose their own topics. The majority of the teachers conducted projects concurrently with the course. The most frequent amounts of class time spent on projects was found to be one, three, and four weeks. Forty-one percent of the teachers interviewed devoted one week or no class time towards projects.

Teachers appeared to place greatest value on the process aspects of biology in connection with objectives of the project method and achievement of objectives by projects dealing with insect behavior. The most important objectives of projects according to the teachers in this inquiry were the following items: to develop and encourage attitudes of inquiry, to give each student an opportunity to do an in-depth study in an area of his interest, and to encourage a respect and feeling for living things. The objectives that teachers felt would most likely be achieved by projects dealing with insect behavior were the items "to develop and encourage attitudes of curiosity and enquiry" and "to enable students to practise methods of proper scientific reporting".

The major advantages of projects involving insect behavior were felt to be the development of skill in scientific thinking and

problem-solving, the provision for active student involvement, the illustration of biological principles, and the provision for individualized instruction. The major problems were felt to be lack of proper equipment, lack of adequate reference materials, exercises that were too time consuming, and insufficient teacher background in collecting and culturing techniques.

It was found that 94.4% of the teachers surveyed used live organisms and that 83.3% used feral organisms. However, the diversity of organisms utilized by each teacher and the length of time the organisms were used were found to be very low. Although 83.4% of the teachers reported using insects during the period 1969 to 1973, only 33.3% were found to be using insects at the time of the interview. Most teachers indicated that they had used only three insect species over the past four years and in most cases only for a short period of time. The most frequently used insects were <u>Drosophila</u>, houseflies, grasshoppers, and ants. Most of the insects used were collected locally by the students. All teachers using insects also reported attempts at culturing them.

Although 72.2% of the teachers reported the study of behavior in their classrooms, projects involving behavior often accounted for only one to 20% of all projects being conducted at the time of the interviews. Only a narrow range of organisms and topics were being investigated. Only three teachers reported projects on insect behavior currently being conducted at the time of the interview. The most common types of studies involving insects were found to be genetics, taxonomy, general behavior, physiology, and social behavior. Although teachers listed a total of 50 species of animals used in

projects involving behavior during the period 1969 to 1973, 78% of these were reported by only one teacher each and most teachers listed only three to five organisms. Four of these teachers had less than four years teaching experience. The groups most frequently used were mammals, birds, and invertebrates. Most of the invertebrates were insects. Only two species of plants were commonly used by teachers and all plants reported were commercial species.

Utilization of Projects on Insect Behavior

The information obtained from the teacher interviews was used to devise 12 projects dealing with insect behavior. This information was supplemented by recommendations from the available literature and examination of equipment used by the Department of Entomology at the University of Alberta. These projects were devised between June 1 and July 31, 1973. Fourteen secondary school biology students conducted projects on insect behavior in the fall semester. A total of 10 adult insect species and four larval forms were utilized in the six student guides followed by these students. The students were interviewed between December 14 and December 20, 1973.

Students who had conducted projects on insect behavior indicated that the main advantages of such projects were the following items: permits the student to observe and develop an appreciation for live animals, allows the student to learn content of special interest, and allows the student to learn content relevant to him. The main problems reported by the students were the unavailability of adequate insects and the lack of adequate library reference materials. Two additional potential problems identified by the writer were

difficulties in experimenting with live animals and difficulties in using the project approach. Both students and teachers indicated that lack of space, difficulty in maintaining and culturing insects, and difficulty in conducting experiments with insects were minor problems.

The two main values of the student guides used were reported to be the provision of background information and the provision of guidance in experimentation and interpretation of results. All students indicated satisfaction with the format of the project guides. The main changes suggested by the students were changes in techniques based on the students' own experiences and the addition of exercises devised by the students to replace or supplement those in the guides.

II. CONCLUSIONS

Four interrelated fields were investigated in this inquiry. These were the use of projects, the use of live organisms, the study of animal behavior and plant tropisms, and the study of insects. From the teacher and student interviews conducted and from the implementation of specific projects in the classroom, the writer would propose the following generalizations concerning each of these aspects of the secondary school biology program.

First, to the extent that the teachers in the initial survey were representative of biology teachers in the province, it would appear that most teachers are using the project method in their classrooms. It would also appear that these teachers view projects as being most valuable in the development of process skills and scientific attitudes and in providing for active involvement and individualized instruction. Students, on the other hand, appear to

feel projects are most valuable in developing an understanding of and appreciation for live organisms and in providing content which is relevant and interesting to the student.

Second, it would appear that although live organisms are being used to a greater extent in the classroom than related studies have indicated, these organisms are being used only for short periods of time. Furthermore, there appears to be an inefficient utilization of local organisms. Only a small variety of species are being used and in most instances these organisms are being used to investigate only one or two aspects of biology.

Third, from the success of the projects conducted in relation to this inquiry, it would appear that insects are particularly suitable for projects in secondary school biology classes. Among the advantages found in using insects were that they required little space, were available locally, were easy to maintain and culture, required little expense, and were easy to experiment with.

Fourth, from the success of the student guides on insect behavior, it would appear that such projects are suitable at the secondary school level. Not only did the projects require a minimum amount of space and unsophisticated equipment, but they were relatively easy to conduct and readily adaptable to the individual interests of the students. Furthermore, the projects were used not only to illustrate the principles of behavior, but also to illustrate principles in a variety of related fields of biology.

III. RECOMMENDATIONS

Recommendations for Utilization of Projects

From the preceding conclusions, the writer would propose the following recommendations concerning each of the aspects of the secondary school biology program investigated. If projects are to be utilized for the development of process skills and scientific attitudes, it would appear to the writer that projects should be of an enquiry nature. If projects are to provide for individualized instruction, it would further appear that a wide variety of project topics must be available for the students to choose from. These two requirements place considerable demands on the classroom teacher, both in terms of constructing such projects and in terms of guiding students in conducting their experiments. If projects are to achieve these two objectives, project guides must be made available to provide assistance to both teachers and students. Such project guides would have to provide adequate background information and suggestions for experimentation and interpretation to be self-contained, but they would have to be open-ended to allow for individual interests and initiative.

If projects are most valuable in developing an understanding of and appreciation for living organisms, it would appear to the writer that projects should involve live organisms as frequently as is possible. This places additional demands on the classroom teacher both in providing live organisms and in acquainting students with their maintenance and utilization. If projects are to achieve this objective, a summary of maintenance facilities for a variety of

organisms must be made available to alert teachers to possible sources and uses of local resources.

From the relatively low incidence of insect utilization revealed in this inquiry, it would appear that the teachers who were interviewed have neglected this readily available natural resource. A minimal number of problems were encountered in the utilization of insects in this inquiry, and it would be the recommendation of the writer that teachers should be encouraged to recommend the use of insects in student projects. Similarly, the low incidence of projects dealing with behavior would appear to indicate that this topic has been neglected by the teachers in this inquiry. Relatively few problems were encountered in conducting projects dealing with insect behavior in this inquiry, and it would be the recommendation of the writer that teachers should be alerted to the possible types of investigations that can be conducted in this field.

<u>Recommendations for Implementation of Projects on Insect Behavior</u>

The following recommendations for the implementation of projects involving insect behavior have been derived from the projects implemented as part of this inquiry. Although these projects dealt only with insect behavior, it is the view of the writer that the following generalizations are equally applicable to projects involving other live organisms and other topics.

1. Teachers and students should have a clear concept of the objectives of the project method.
2. Students should have a clear concept of the specific objectives of the topic they are investigating.

3. A project selection form should be used to decrease problems in choosing and conducting projects.
4. Student project guides should be provided to assist students in conducting their projects. These guides should provide the student with both generalizable and incisive knowledge. The format of the guides used in this inquiry was found to be particularly suitable.
5. Students should be given training and guidance in using the project method.
6. Students should be given assistance and encouragement in the collection and utilization of local organisms.
7. Adequate library reference material should be available for each topic investigated, or a summary of information essential for experimentation should be provided by the teacher.
8. Organisms selected for projects should require a minimum of care and be suitable for experimentation.
9. The topic to be investigated should be within the capabilities of the students and within the resources of the school. A variety of topics should be available to meet the requirements of both the concrete operational student and the formal operational student.

Recommendations for Further Research

This inquiry has revealed several areas which require further investigation. First, more research on the relationship between the variables investigated in this inquiry and the methodologies employed

by teachers with respect to the use of projects and live organisms in the classroom would be enlightening. Such research might reveal the reasons for current instructional methodologies, and as such, possible ways in which the utilization of projects and live organisms can be improved, both in the initial training of teachers and in workshops for practicing teachers.

A wider and more comprehensive survey of secondary school biology teachers to determine what live organisms are being studied and how they are being utilized would also be of value in providing more accurate information on the use of local resources throughout the province. This information could serve as a guide for further research by indicating which organisms and topics are being investigated most frequently and which are being neglected in the classroom. This information could also be used as the basis for the development of guides providing information on the value and maintenance facility of specific organisms as suggested for teachers in England by Kelly and Wray (1971). There appears to be a need for alerting teachers to the value of organisms and topics they are not acquainted with.

More information on how live organisms can be utilized in the classroom is also needed to improve efficiency in the utilization of local resources. Studies similar to those conducted by Jacknicke (1968) and Dyke (1970) could be conducted for other groups of organisms. The development of student and teacher guides for other organisms and for other topics similar to the guides devised in this inquiry would be of assistance to both students and teachers in the selection and implementation of projects.

A more detailed study on the availability of local insects and on methods for maintaining and culturing local insects is also needed. Other ways in which insects can be utilized could also be investigated and research on culturing techniques for other groups of animals would also be of value to the classroom teacher.

To the knowledge of the writer no studies have been conducted on the value of the project method nor on its effect on the learning abilities of the student within the Alberta context. A comparison between the project method and other instructional methods with respect to the learning of biological principles and the development of scientific attitudes and process skills could be made. Similarly, the use of live organisms could be evaluated with respect to the learning of biological content and the development of the process aspects of biology. Each of these studies would hopefully contribute to the actualization of the potentiality that exists in the interaction between the teacher, the students, and the live organism in the project approach to secondary school biology.

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APPENDIX I

SCHOOL SYSTEMS COVERED IN THE INQUIRY

Crow's Nest Pass School Division Number 63

Pincher Creek School Division Number 29

Willow Creek School Division Number 28

Cardston School Division Number 2

Lethbridge District Number 51

Lethbridge Catholic Separate District Number 9

Lethbridge County Number 26

APPENDIX II

LETTER TO SUPERINTENDENTS OF SCHOOLS

1205 Campus Tower
11145 - 87 Ave.
Edmonton, Alberta
February 26, 1973

Dear _______________:

The (name of school system) has been selected as one of the school systems in southwestern Alberta to be included in a survey to determine the use of insect behavior projects in secondary school biology courses. This survey will concentrate on teacher utilization of projects and insects, and on teacher opinions concerning the study of behavior. The contribution of those teachers who decide to participate in this study will involve approximately fifteen minutes in consultation with me.

The results of this interview will be used as part of a thesis for a Master of Education degree under the advisorship of Doctor C.G. Hampson.

Permission to contact the secondary school biology teachers in the (name of school system) to request their assistance in this inquiry would be deeply appreciated. It is hoped that this inquiry will be of practical value to the teachers in this province. A stamped, self-addressed envelope is enclosed for your convenience. Thanking you in advance for your assistance.

Yours truly,

Robert A. Franz

APPENDIX III

LETTER TO TEACHERS REQUESTING AN INTERVIEW

1205 Campus Tower
11145 - 87 Ave.
Edmonton, Alberta
April 9, 1973

Dear ______________:

(Name of school system) has been selected as one of the school systems in southwestern Alberta to be included in a survey to study the use of insect behavior projects in secondary school biology. The purpose of this survey is twofold: first, to determine the nature of present teacher utilization of projects and insects; and second, to obtain teacher opinions on the study of behavior to use as guidance in the selection and synthesis of insect behavior projects. The results of this interview will be used as part of a thesis for a Master of Education degree under the advisorship of Doctor C.G. Hampson.

If you decide to participate in this survey, your contribution will involve approximately fifteen minutes in consultation with me after or during school or at your home. Your assistance in this inquiry would be deeply appreciated. It is hoped that this study will be of practical value to the teachers in this province.

I will be calling you in the near future to determine if, and where, this interview will be convenient for you. Thanking you for your cooperation.

Yours truly,

Robert A. Franz

APPENDIX IV

TEACHER INTERVIEW GUIDE

School ______________ Date ____________ Sex __________ No. ___

No. Full Yr. Biology Courses _____ Teaching Experience ___

No. Full Yr. Ethology Courses _____ Yrs. of University Training ___

No. Full Yr. Entomol. Courses _____ Year of Graduation ___

No. Full Yr. Methods Courses _____ Yr. Last Attended University ___

Accessibility of Natural

Resources: ____________

____

____

	Class			
	Nonbio.	B. 10	B. 20	B. 30
Text				
No. of Classes				
Class Size				

	B. 10	B. 20	B. 30
1. What number of projects currently being conducted take each of the following forms? a. individual projects b. small group projects c. entire class projects			
2. What number of these projects deal with behavior?			
3. What number of these projects deal with live organisms?			
4. What number of these projects deal with live insects?			
5. What number of these projects deal with insect behavior?			
6. Are these projects chosen by the teacher, the pupil, or by both of these methods?			
7. Are these projects run concurrently with the regular biology course or as a unit of time?			
8. Approximately how many weeks of class time are spent on student projects?			

	9	10
9. How would you rank the following objectives of projects in importance? (5 very high importance, 4 high importance, 3 medium importance, 2 low importance, 1 very low importance)		
a. To give each student an opportunity to do an in-depth study in an area of his interest		
b. To encourage students to formulate questions for investigative purposes		
c. To further familiarize students with research methods		
d. To enable students to practise methods of proper scientific reporting		
e. To permit the development of empathy with the scientific researcher		
f. To develop and encourage attitudes of curiosity and inquiry		
g. To encourage a respect and feeling for living things		
h. To provide material supplemental to the course		
i. To evaluate the effect of scientific discoveries		
j. To allow students to evaluate the work of peers		
k. Other (identify)		

10. To what extent do you feel projects dealing with insect behavior can achieve the preceding objectives? (5 very high achievement, 4 high achievement, 3 medium achievement, 2 low achievement, 1 very low achievement)

11. To what extent do you feel the following items are advantages in conducting projects dealing with insect behavior? (5 very high advantage, 4 high advantage, 3 medium advantage, 2 low advantage, 1 very low advantage)

   a. Stimulates interest and motivation .... ______

   b. Provides for individualized instruction .... ______

   c. Stimulates further research .... ______

   d. Develops an appreciation for living organisms .... ______

   e. Provides for active involvement .... ______

   f. Can be used to illustrate biological principles ...... ______

   g. Develops skill in scientific thinking and problem-solving .... ______

   h. Develops scientific attitudes .... ______

   i. Provides student with content of special interest .... ______

   j. Develops techniques in using laboratory equipment .... ______

   k. Other (identify)

12. To what extent do you feel the following items are problems in conducting projects dealing with insect behavior? (5 very great problem, 4 great problem, 3 medium problem, 2 little problem, 1 very little problem)
    a. Lack of proper equipment .... ______
    b. Lack of adequate space .... ______
    c. Lack of adequate reference material .... ______
    d. Student lacks sufficient biological background .... ______
    e. Classes are too large .... ______
    f. Lack of student interest .... ______
    g. Too time consuming .... ______
    h. Insufficient teacher background in collecting and culturing techniques .... ______
    i. Inadequate knowledge of what insects are available ... ______
    j. Adequate insects are unavailable the year round ...... ______
    k. Insects are too difficult to handle in experiments ... ______
    l. Insects are too difficult to culture .... ______
    m. Insects are too difficult to maintain over holidays .. ______
    n. Other (identify)

13. List as specifically as possible those insects used during the school years 1969/70 to 1972/73 and indicate:
    a. if they were used in projects or in laboratory exercises
    b. if they were purchased, collected by pupils, or collected by the teacher
    c. if there were any attempts to culture the insects
    d. the number of cultures maintained
    e. how long the insects were used (in weeks)
    f. the reason the insects were used.

Insect	Proj. Lab.	Purchased Pupil Col. Teach. Col.	Culture	No. Main-tain.	Weeks Used	Reason Used

14. List those ethology projects which have been conducted during the school years 1969/70 to 1972/73 and the organisms used.

APPENDIX V

LETTER TO TEACHERS OFFERING PROJECT GUIDES INVOLVING INSECT BEHAVIOR

Coleman, Alberta
September 1, 1973

Dear _______________:

As a result of the interviews conducted last May, twelve projects dealing with insect behavior have been designed. The objectives emphasized in these projects are those indicated as being the most important by teachers in that survey. The problems and other concerns indicated by the teachers have also been carefully considered. The experiments chosen utilize equipment which is usually found in the school or which can be made by the student. The lack of reference material, student background, and teacher background has hopefully been overcome by including sections on behavior theory, collection procedures, and culturing techniques in the student guides.

I am enclosing the following references with regards to these projects for your perusal:

58. Insect Behavior Projects (Teacher Guide): a summary of the philosophy, objectives, content, and implementation of projects dealing with insect behavior.

58. Insect Behavior Projects (Student Guide): in addition to the above, a summary of the nature of the twelve projects.

If you are interested in using any of these guides for class projects or for laboratory exercises, or if any of your students this term are interested in conducting projects dealing with insect behavior, I would be pleased to send a copy of the appropriate guide(s) to you. Unfortunately, it is impossible to provide a copy of all twelve guides at this time, not only because of the cost involved but also since the guides are subject to revision.

This revision will be based on the opinions and experiences of those using the guides. Should you wish to use any of the guides, it would be deeply appreciated if at the conclusion of the project I would be able to interview those students using the guide. A copy of the proposed interview is enclosed along with a stamped, self-addressed envelope and request form for your convenience.

If you wish more information on these projects I will be willing to answer any questions you may have. Also, if during the implementation of the projects any problems or questions arise, I would be pleased to offer any assistance I can. Teacher guides are proposed for each of the projects and hopefully will be available before the end of the semester.

Thanking you again for your former assistance and hoping to hear from you in the near future.

Yours truly,

Robert A. Franz

Encl: Teacher Guide (Number 58)
Student Guide (Number 58)
Proposed Interview Guide
Request Form
Self-addressed envelope

INSECT BEHAVIOR PROJECTS

REQUEST FORM

Teacher: ______________________________

Address: ______________________________

____

____

Please send one copy of the following Student Guides:

Guide Number	No. of Students Using Guide	Teacher Guide Requested

The students using the above guides may be interviewed upon completion of the project.

APPENDIX VI

58. INSECT BEHAVIOR PROJECTS (TEACHER GUIDE)

RATIONALE

> There are few who would deny the need to understand more fully the roots of human behavior. The controversies aroused by Konrad Lorenz' book On Aggression and Desmond Morris' The Naked Ape reveal how little we know about this subject. This knowledge can come only from a far broader knowledge of animal behavior generally than we now possess. And since behavior evolves in and is closely conditioned by the community in which an animal occurs, it is fully understandable only in an ecological context. It is this field--behavior and environment, or ethology and ecology--that is truly the science of tomorrow.

This quotation from H.E. Evans (1970) has been the philosophy behind the construction of these projects. A significant aspect of behavior studies is that such investigations give us a better understanding of the entire organism. A student cannot obtain a full understanding of biology without working with live organisms, and of the variety of organisms available, insects lend themselves well for this purpose. Insects are readily available most of the year, are relatively easy to maintain, and can be used in simple experiments with minimum difficulty in manipulation and observation.

To truly appreciate the complexity and mechanism of living processes, a student must observe more than just the parts of an organism, he must observe the entire creature as it interacts with its environment and fellow beasts. Through observation of insect behavior, the student can develop an appreciation of the insect (and other organisms) as a form of life not really so different from the student himself. Perhaps most important of all, children are basically interested in living creatures, and by studying living organisms in the classroom this interest can be nurtured and the appropriate attitudes towards living things developed. Printed pages in a text, the irritating odor of formaldehyde, and the crunch of dried specimens are not the sights, not the aromas, nor the sounds of life.

OBJECTIVES

In keeping with the general objectives of secondary school biology and the purposes of biology projects as enumerated in the Alberta biology curriculum guide (1971), the exercises included in these projects have been selected in an attempt to achieve basic educational goals. These objectives include the following items:

1. To give each student an opportunity to do an in-depth study in an area of his interest.
2. To encourage students to formulate questions for investigative pruposes.
3. To further familiarize students with research methods and procedures.
4. To enable students to practise methods of proper scientific reporting.
5. To permit the development of empathy with the scientific researcher.
6. To develop and encourage attitudes of curiosity and inquiry.
7. To encourage a respect and feeling for living things.
8. To provide material supplemental to the course.

PROJECT DESIGN

Each project is summarized in the accompanying student guide. Each of the 12 projects consist of the following nine sections:

1. An OVERVIEW summarizing the topics involved in that particular aspect of behavior.
2. A brief summary of the background THEORY in which basic concepts are defined and explained. Special considerations in experimental techniques are included where necessary.
3. A list of MATERIALS needed for collection, culturing, and experimentation. Most equipment is commonly found in the school or home. Special equipment is indicated in the accompanying student guide. This equipment can be purchased at low cost or can be constructed by the student. Instructions for the construction of such equipment is provided in each project.
4. A summary of COLLECTION procedures and where to find the recommended insect. All insects suggested are common and readily available. Some can be purchased from local pet stores or supply houses. The majority of the projects can be conducted with any insect. Students are not limited to the insects suggested.
5. Techniques for CULTURING from eggs to adults are included in all projects should the exercises be conducted during the winter months. In all cases a minimum amount of care is needed and the equipment is commonly found in the school. Most projects do not require culturing.
6. The basic PROCEDURES for carrying out the projects are outlined. These are designed so that portions can be deleted or added as determined by the time devoted towards projects, the insects and equipment available, the abilities of the student, and the number of students working on the project.
7. A series of questions orienting the student toward the conclusion and INTERPRETATION of the results. These are designed to initiate student analysis of the data collected.
8. A list of EXTENDED EXERCISES provide supplemental exercises which can be conducted in addition to those in the project or which can be substituted for portions of the project. Here the student is

required to devise his own procedures.

9. Student REFERENCES are listed for more detailed research. Each project is designed so that it can be conducted from the theory provided so that additional texts are not essential.

IMPLEMENTATION

In addition to the guidelines suggested in the Alberta biology curriculum guide (1971), the following suggestions are offered with respect to these particular projects:

1. These projects are not cookbook guides requiring strict adherence. They are designed so that procedures can be modified according to local circumstances. Students should be encouraged to adapt the project to meet their own needs and interests.
2. The insects recommended are not limitations. Any insect can be substituted except for projects 580, 581, 588, and 58e. These four projects deal with species unique traits in the theory portion of the guide. However, other insects can be used if the appropriate background is known or if the student is capable of applying the guide to unknown situations.
3. The projects are not graded according to student ability or background. As such, the depth to which the project is carried out will vary from grade to grade and individual to individual. The teacher may wish to read the guide before giving it to the student so that assistance can be given in selecting portions of the project suitable for that student.

REFERENCES

Alberta Department of Education. Biology 10, 20, 30. Edmonton: Alberta Department of Education, 1971.

Evans, H.E. Life on a Little-known Planet. New York: Dell Publishing Co., Inc., 1970. (A description of the lives and habits of various insect species.)

SOURCES

The following references provide additional suggestions on the implementation and evaluation of projects.

Allen, Dorothea. Research Projects in High School Biology. West Nyack: Parker Pub. Co., Inc., 1971.

Miller, David F. and G.W. Blaydes. Methods and Materials For Teaching the Biological Sciences, second edition. Toronto: McGraw-Hill Book Co., Inc., 1962.

Richardson, John S. Science Teaching in Secondary Schools. Englewood Cliffs: Prentice-Hall, Inc., 1959.

Thurber, Walter A. and Alfred T. Collette. Teaching Science in Today's Secondary Schools, second edition. Boston: Allyn and Bacon Inc., 1965.

APPENDIX VII

58. INSECT BEHAVIOR PROJECTS (STUDENT GUIDE)

PURPOSE

The word "biology" is derived from the Greek bios meaning the mode of life plus -ology meaning the science of. Biology, then, is the science of life, and to fully understand life, it follows that one should study living organisms. Insects are recommended as experimental animals since they are easy to maintain and to work with and they illustrate the basic principles of life found in all organisms. The study of behavior is recommended as an area of research since behavior is closely related to all other aspects of biology, either as a result of or as a cause of other biological processes. As such, the projects summarized in this guide are designed not only to illustrate insect behavior, but also to illustrate behavior patterns common to all forms of life and to indicate the relationship of behavior to other aspects of biology.

OBJECTIVES

The basic objectives of these projects are to illustrate the procedures followed by biologists in their research and to introduce you to the major concepts of animal behavior. More specifically, the goals of these projects include the following objectives:

1. To provide an opportunity for you to do an in-depth study in an area of animal behavior.
2. To familiarize you with research methods and procedures of a biologist.
3. To provide an opportunity for you to practise methods of proper scientific reporting.
4. To provide you an opportunity to practise inquiry skills.
5. To encourage a respect and feeling for living things.
6. To provide an opportunity for the development of individual skills and interests.
7. To develop an understanding of the life and concerns of a scientific researcher.

PROJECT CONTENT

Each project summarized in this guide consists of the following nine sections:

1. An OVERVIEW summarizing the project guide.
2. A summary of the THEORY behind the topic with an explanation of the major concepts and suggestions on how to carry out the experimentation.

3. A list of MATERIALS needed for collection, culturing, and experimentation. Most equipment is commonly found in the school or home. Special equipment listed in the summary on the following pages can be purchased at low cost or made. Instructions for making the equipment is found in each guide.
4. A summary of COLLECTION procedures and where to find the insects. All insects are common in this area or can be purchased.
5. Techniques for CULTURING from eggs to adults. Most projects do not require culturing and methods and materials needed for maintaining insects over winter are kept to a minimum.
6. The basic PROCEDURES for carrying out the projects are outlined.
7. A series of questions for assistance in INTERPRETATION of results.
8. A list of EXTENDED EXERCISES which can be used in addition to those listed under procedures or which can be substituted for parts of the procedure.
9. Student REFERENCES for more detailed research.

USE OF PROJECT GUIDE

1. These guides do not have to be followed strictly. They should be modified to meet your own needs, interests, and resources.
2. The insects suggested do not have to be used. Any insect can be substituted. However, projects 580, 581, 588, and 58e deal with characteristics of specific species: if you wish to use other insects check with your teacher first to find out if background information is available.

SUMMARY

Explanation of descriptions:

1. The numbers (580, 581) indicate the number of the guide.
2. Recommended insect: an asterisk (*) indicates that additional information will be needed if a different insect is used. Otherwise any alternative can be used.
3. Special equipment: this lists materials which may not be in the school. Instructions on how to make the equipment are found in each guide.
4. Culturing: materials and food needed to maintain the insect are listed if the material is not commonly found in the school or home.
5. Time: the time required to complete the project in most cases can be modified, ranging from one week to two months, depending on how much is done. Exceptions are noted in the summary.

PROJECT
NUMBER

580. GENERAL BEHAVIOR

Recommended insect: ant (any number and species)*
Special materials: observation nest
Culturing: optional
Time: optional
Overview: An ant colony is established and the individual, social, and specialized behaviors of the species is observed, described, and analyzed.

581. RHYTHMIC BEHAVIOR, ENDOGENOUS PERIODICITY

Recommended insect: milkweed bug (*Oncopeltus fasciatus*)* (suggested: 50 pair)
Special materials: temperature and light control, red light
Culturing: required (food: milkweed seeds)
Time: approximately 45 days including culturing
Overview: Rhythmic behavior (behavior occurring in a regular cycle) of the milkweed bug is studied by raising insects from eggs under different durations of light and then observing frequencies of feeding and reproducing.

582. ORIENTATION, KINESES AND TAXES IN GENERAL

Recommended insect: noctuid moths (any species and number), adults and caterpillars (larvae)
Special materials: temperature gradient, humidity gradient, choice chamber
Culturing: recommended (food: host plant, moss)
Time: optional
Overview: The responses of adult and larval moths are investigated by exposing them to different chemicals, temperatures, humidity, light, and gravity.

584. REACTIONS AND RESPONSES TO GENERAL AND MECHANICAL STIMULI

Recommended insect: dragonfly, diving beetle, housefly
Special materials: none
Culturing: optional (food: pond organisms, earthworms, goldfish food; aquarium)
Time: optional
Overview: The responses of these three species to touch, sound, and gravity are investigated.

PROJECT
NUMBER

585.1. REACTIONS AND RESPONSES TO CHEMICAL STIMULI

Recommended insect: Monarch butterfly (*Danaus plexippus*) adults and larvae
Special materials: milkweed leaves
Culturing: optional (milkweed plants)
Time: optional
Overview: The feeding behavior of adult butterflies to different concentrations of sugar solutions is studied. In the second part, responses of larvae to the odor of the host plant and experimental leaves is investigated. Each part can be treated as a single project.

585.2. REACTIONS AND RESPONSES TO TEMPERATURE AND HUMIDITY

Recommended insect: houseflies (*Musca domestica*): larvae
Special materials: temperature gradient, humidity gradient
Culturing: optional (wheat, alfalfa, malt)
Time: optional
Overview: The responses of larvae to different temperature and humidity ranges is studied with reference to their movements and "preferences". Adults can be used in addition or instead of the larvae. Any species of maggots can be used.

586.1. REACTIONS AND RESPONSES TO VISUAL STIMULI

Recommended insect: larval blowflies, adult backswimmer
Special materials: 25-watt bulbs, two desk lamps; aerated aquarium for the backswimmer
Culturing: optional (blowfly: rearing can and fresh liver; backswimmer: pond organisms)
Time: optional
Overview: The responses of these two species to light intensity, direction and wavelength (color) are studied with reference to movements and "preference". Experiments with backswimmers can be considered a separate project.

587. LEARNING

Recommended insect: mealworm larvae (*Tenebrio molitor*)
Special materials: maze in the shape of a "T"
Culturing: optional (wheat flour, canned dog food)
Time: approximately 10 trials/day for 20-30 days
Overview: The learning ability of the mealworm larva is determined by training it to enter one of the two arms of a T-maze.

PROJECT
NUMBER

588. PSYCHIC PHENOMENA, INSTINCT AND INNATE BEHAVIOR

Recommended insect: fruit fly (two species: *Drosophila melanogaster* and *D. virilis*)*
Special materials: observation chamber, magnifying lens or dissecting microscope
Culturing: required: culture media or agar, corn meal, and sodium proprionate
Time: optional (two to three weeks for development from egg to adult)
Overview: The reproductive behavior (courtship movements) of two species of fruit flies to members of their own species and to other species are compared and analyzed to determine the role of this instinct as a method of separating species. Insects other than fruit flies can be used but courtship movements may differ from those described in the guide.

58e. COORDINATED BEHAVIOR: Construction Behavior

Recommended insect: larval caddis flies (any species)*
Special materials: none
Culturing: optional (pond organisms, aerated aquarium for stream species)
Time: optional
Overview: The cause, variability, procedure, and final product of case building in larval caddis flies are studied by observing them build and repair cases and by providing them with foreign materials. Construction by insects other than caddis flies can be studied if references on their behavior is available.

58t. MOVEMENT

Recommended insect: larval phantom midge, adult cockroach, adult housefly
Special materials: Styrofoam ball, insect race track
Culturing: optional (pond organisms for midge; wheat, alfalfa, and malt for housefly)
Time: optional
Overview: The walking and running movements of the cockroach, the swimming movement of the phantom midge, and the flight of the housefly are studied. Each of these can be treated as a single project and any other insect can be used.

PROJECT
NUMBER

58f. COMPARATIVE BEHAVIOR STUDIES: Grooming

Recommended insect: American cockroach, German cockroach, house cricket, mealworm beetle, milkweed bug, housefly
Special materials: none
Culturing: optional (see previous projects for special culturing materials)
Time: optional
Overview: The grooming behavior of the above insects when coated with chalk dust is studied and compared to determine the relationship between structure and function, between grooming and habitat and life habits, and between species to arrive at general concepts concerning insect grooming behavior. Any insect can be used in place of those listed.

APPENDIX VIII

STUDENT INTERVIEW GUIDE

Name and number of project used: ______________________ No. ____

Insect(s) used: ______________________________________

1. To what extent do you feel the following items are advantages in conducting projects dealing with insect behavior? (5 very high advantage, 4 high advantage, 3 medium advantage, 2 low advantage, 1 very low advantage)

   a. Allows the student to learn content relevant to him ... ______

   b. Allows the student to study on his own .... ______

   c. Provides ideas for further research .... ______

   d. Permits the student to observe and develop an appreciation for live animals .... ______

   e. Allows the student to learn how to work like a scientist .... ______

   f. Allows the student to learn content of special interest ______

   g. Allows the student to learn how to use laboratory equipment .... ______

   h. Other (specify)

2. To what extent did you find the following items were problems in conducting your project on insect behavior? (5 very great problem, 4 great problem, 3 medium problem, 2 little problem, 1 very little problem)

   a. Lack of proper equipment .... ______

   b. Lack of adequate space .... ______

   c. Lack of adequate library reference material .... ______

   d. Lack of sufficient biological background .... ______

   e. Lack of interest .... ______

   f. Too time consuming .... ______

   g. Adequate insects were unavailable .... ______

   h. Insects were too difficult to handle in experiments ... ______

   i. Insects were too difficult to culture .... ______

   j. Insects were too difficult to maintain over holidays .. ______

   k. Practical exercises were too difficult .... ______

   l. Devising your own exercises was too difficult .... ______

m. Project required too much work .... ______

n. Too difficult to regulate time properly .... ______

o. Other (specify)

3. The project guide you used contained the following nine sections. Indicate in the first column which aspects were helpful to you and how they were helpful. Indicate in the second column how the guide might be changed to be more helpful.

	HELPFUL	CHANGE
Overview:		
Theory Notes:		
Materials List:		
Collection Suggestions:		
Culturing Suggestions:		
Procedures Suggested:		
Guide to Interpretation:		
Extended Exercises Suggested:		
References Listed:		

APPENDIX IX

PROJECT SELECTION FORM

Course __________ Section _______ Date ______________ Draft _______

1. Student: Reason for selecting the topic:

________________________ ____

________________________ ____

________________________ ____

2. Topic: ____

3. Purpose of the project: ____

____

____

4. Methods of Investigation (If experimental, indicate the hypothesis, variables, control groups, and test groups.)

5. Organism(s) to be used: ____

6. Equipment and Materials needed from the school:

7. Special cautions or limitations:

8. Scope of topic and anticipated time schedule:

9. Resources and References available (indicate location):

** If members are to be graded individually, check here: ____________ and indicate on the back the composition subtopic and research subtopic for each student.

Instructor's Comments: Revise ______

Accepted ____

APPENDIX X

TEACHER PROFILE AND PROJECT UTILIZATION

VARIABLE		NO. OF TEACH.	USED BEHAVIOR PROJECTS				USED INSECT PROJECTS				USED INSECT BEHAVIOR PROJECTS			
			YES		NO		YES		NO		YES		NO	
			NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
Entomology Courses	Yes	7	5	71	2	29	3	43	4	57	2	29	5	71
	No	10	8	80	2	20	3	30	7	70	1	10	9	90
Year Last Attended University	52-62	4	1	25	3	75	1	25	3	75	1	25	3	75
	67-69	4	4	100	0	0	0	0	4	100	0	0	4	100
	70-71	5	4	80	1	20	4	80	1	20	1	20	4	80
	1973	4	4	100	0	0	1	25	3	75	1	25	3	75
Biol. 20 Text*	Yellow	9	7	78	2	22	4	44	5	56	2	22	7	78
	Green	5	4	80	1	20	1	20	4	80	0	0	5	100
Biol. 30 Text*	McE.	11	9	82	2	18	2	18	9	82	1	9	10	91
	W. and McE.	5	3	60	2	40	0	0	5	100	0	0	5	100

VARIABLE		NO. OF TEACH.	METHOD OF CHOICE				WEEKS OF CLASS TIME SPENT							
			PUPIL		BOTH		0		1 - 2		3 - 4		5 - 8	
			NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
Entomology Courses	Yes	7	3	43	4	57	1	14	1	14	4	57	1	14
	No	10	9	90	1	10	1	10	4	40	3	30	2	20
Year Last Attended University	52-62	4	3	75	1	25	0	0	1	25	3	75	0	0
	67-69	4	2	50	2	50	1	25	1	25	0	0	2	50
	70-71	5	4	80	1	20	1	20	2	40	1	20	1	20
	1973	4	3	75	1	25	0	0	1	25	3	75	0	0
Biol. 20 Text*	Yellow	9	7	78	2	22	1	11	3	33	5	56	0	0
	Green	5	2	40	3	60	1	20	1	20	3	60	0	0
Biol. 30 Text*	McE.	11	7	64	4	36	2	18	3	27	3	27	3	27
	W. and McE.	5	4	80	1	20	0	0	2	40	2	40	1	20

* Aspect of project utilization applies only to this course
Yellow: Biological Sciences Curriculum Study, Yellow Version (1968)
Green: Biological Sciences Curriculum Study, Green Version (1968)
McE.: McElroy et. al. (1968)
W.: Weisz (1963)

APPENDIX XI

REFERENCES FOR THE COLLECTION AND CULTURING OF INSECTS

Beirne, Bryan P. Collecting, Preparing, and Preserving Insects. Ottawa: Queen's Printer, 1963.

Borror, Donald J. and Dwight M. DeLong. An Introduction to the Study of Insects, revised edition. Toronto: Holt, Rinehart and Winston, Inc., 1964.

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APPENDIX XII

REFERENCES FOR THE STUDY OF BEHAVIOR

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Polt, J.M. "Experiments in Animal Behavior", American Biology Teacher, 33:472-479, 1971.

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